Study on Water pollution of Vairab River from Nowapara, Jessore to Labon Chara, Khulna

by

(Firoz Ahmed)

A Thesis Submitted in Partial Fulfillment of The Requirements for the Degree of Master of Philosophy in the Department of Chemistry

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May 2014

DEDICATED

TO

MY DEAR PARENTS

AND BELOVED

WIFE AND KIDS

Declaration

This is to certify that the thesis work entitled "*Study on Water pollution of Vairab River from Nowapara, Jessore to Labon Chara, Khulna*" has been carried out by *Firoz Ahmed* in the Department of *Chemistry*, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above thesis work or any part of this work has not been submitted anywhere for the award of any degree or diploma.

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Approval

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Abstract

Vairab river is the vital source of water in Nowapara, Jessore to Khulna and is being polluted increasingly by effluents discharged from industries, municipal sewage, household wastes, linical wastes and oils. The purpose of this study is to investigate the impact of this wastewater on the river and thus to provide an updated report on the state of water quality of river Vairab. The water sample were collected from different areas in the river Vairab and analyzed for physico-chemical parameters and fresh water elements in the month of July, 2013 to November, 2013. The values of temperature, turbidity, pH, chloride, hardness, DO, BOD, COD, Fe, As, Pb, Cd and Cr in the river water were measured. During study period the temperature, turbidity, pH, hardness, chloride, DO, BOD and COD were found to be 28^0C to 31.5^0C, 37 to 947 NTU, 7.2 to 8.01, 92 to 140 ppm, 9 to 34 ppm, 122 to 5.51 mg/L, 0.22 to 5.79 mg/L and 3.80 to 10.80 mg/L respectively. The concentration of Fe, Pb, As, Cd and Cr were found to be 0.10 to 2.60 ppm, 0.004 to 0.025 ppm, 0.001 to 0.004 ppm, 0.00015 to 0.0094 ppm and 0.001 to 0.006 ppm respectively. From the results of investigation, it was observed that the values of pH, Cl^- , hardness, As, Pb, Cd and Cr were within standard limit but the values of temperature, turbidity, DO, BOD, COD and Fe were not within acceptable limit as recommended by WHO and BDS guidelines. The results obtained from this investigation will help the people of the research area to be conscious for using the water in the Vairab river.

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Nomenclature

Name	**Description**
AAS	Atomic Absorption Spectrometer
APHA	American Public Health Association
As	Arsenic
AWWA	American Water Works Association
BDS	Bangladesh Standard
BOD	Biochemical Oxygen Demand
CCME	Canadian Council of Ministers of the Environment
Cd	Cadmium
COD	Chemical Oxygen Demand
Cr	Chromium
CVT	Contingency Value Method
DO	Dissolved Oxygen
DOE	Department of Environment
DPHE	Department of Public Health Engineering
EBT	Eurochrome Black-T
EC	Electrical Conductivity
EDTA	Ethylene Di-amine Tetra Aceticacid
EPA	Environmental Protection Agency
Fe	Iron
GIS	Geographic Information System
MCL	Maximum Contamination Level
NTU	Nephelometric Turbidity Unit
Pb	Lead
TDS	Total Dissolved Solid
TMDL	Total Maximum Daily Load
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

CHAPTER 1

Introduction

1.1 General

Anthropogenic chemicals have done considerable damage aquatic ecosystem in the past and continue to do so today. In the U.S., about 220000 miles of rivers observed in 2009 were deemed [1] to have significantly impaired ecosystem services, due to pollution by chemicals such as heavy metals, especially mercury, pesticides, ammonia, oils and polychlorinated biphenyls [2]. This can be used as indicator for biodiversity. Water covers 70% of the Earth's surface and makes up over 60% of the human body.

Water pollution affects marine ecosystems, wildlife health, and human well-being. Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). Water pollution occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds. Water pollution affects plants and organisms living in these bodies of water. In almost all cases the effect is damaging not only to individual species and populations, but also to the natural biological communities. It is a well known fact that clean water is absolutely essential for healthy living. Adequate supply of fresh and clean drinking water is a basic need for all human beings on the earth, yet it has observed that millions of people worldwide are deprived of this. The development of industry and agriculture created a number of environmental problems including air and water pollution with their serious effects on human health [3].

Rapid industrialization and urbanization have resulted in elevated emission of toxic heavy metals entering the biosphere [4-5]. An estimate of Witt [6] based on WHO reports suggests that 80% of all human illness in the developing countries is associated with polluted water. It has been suggested that it is the leading worldwide cause of deaths [7-8] and that it accounts for the deaths of more than 14,000 people daily [8]. An estimated 1,000 Indian children die of diarrhea every day (a special report on India 2008). The contribution of geology is to help isolate environmental aspects that may influence the incidence of disease. Bangladesh is facing enormous challenges in meeting the rising freshwater demand due to limited water supply from the available Ground water and Surface water sources as they are affected by the salinity and other water quality problems [9-10]. At present, the principle cause of salinity intrusion in Khulna region is the drop of hydraulic head during the dry period (November to May) into both Surface Water and Ground water of the area [11]. In case of fishery, increased salinity affects spawning ground leading to substantial reductions in the inland open water fishery [12].

As being of divisional headquarter, a large number of industries has been built up in the Khulna city. Most of the industries in Khulna region are reported to have suffered from the increase in salinity. The losses resulted due to increased cost of importing freshwater, frequent leakage of condensers due to uses of saline water and production loss and disruption of power supply from the Goalpara Power station. From December 1975 to June 1976, it was estimated that the increased salinity caused industrial losses of $8 million. During the period 1976-1993, total industrial sectors were estimated to $37 million [13]. Bangladesh is a low lying flat country with big inland water bodies, including some of the biggest rivers in the world is extremely vulnerable to climate change because of its geophysical characteristics [14]. Current world population is 6.8 billion and the estimated population is 9.2 billion for the year 2050 [15]. The world's freshwater is poorly distributed across countries, within countries and between seasons. Demographic factors combined with an increase in per capita demand and a decrease in readily available resources has resulted in the current era of global freshwater scarcity. Rapid urbanization, water pollution and global warming are aggravating the situation. Most of the big cities and settlements developed near the rivers. Simultaneously this urbanization becomes main reason of pollution for these rivers and other water bodies [16]. Surface water quality of the rivers of Bangladesh is highly polluting day by day [17-18].

Nature is the nourisher of all kinds of life system on earth by providing proper environment to the living organisms. Diverse environment is the base for the diversity of lives both of plants and animals. The diverse environment includes land, air and water. Bangladesh has the widest spectrum of inland open water resources and marine resources. The inland open waters have been the major source of fish production in Bangladesh from the time immemorial. But due to different environmental and

destructive anthropogenic activities wild fishes are declining day by day. Water profusely everywhere in all over the country by the insane intrusion of human beings.
Quality of water is generally refers to component of water, which is to be present at the optimum level suitable for growth of aquatic plants and animals. Various factors like water temperature, turbidity, nutrient, hardness, alkalinity, dissolved oxygen (DO) play important role for the growth of plants and animals in the water. On the other hand the biological oxygen demand BOD) and the chemical oxygen demand (COD) indicate the level of pollution of a given water body. Each factor has a specific role in aquatic eco-system. The river plays an important role for fisheries. The rivers also support thousands of people for their bath and other domestic purpose.

The surface water resource is very much essential of the country for its human and animal living, aquatic flora and fauna, navigation, agriculture, etc. It is also necessary for keeping alive the distributaries in the delta and maintaining the brackish water ecosystem along the sea, on an annual cycle [19]. Thus, the surface water is essential for keeping the environment balance of total region, particularly in the estuaries to the south and at the mouth of the rivers. Surface water monitoring is essential for aquatic resources management and flood forecasting [19]. Bangladesh has extensive water bodies that have a high potential for fisheries production [20]. The productivity depends on physico-chemical characteristics of the water body [21]. The population of natural fish species has declined considerably due to increased fishing pressure and various anthropogenic activities leading to siltation, aquatic pollution and loss of natural habitat for spawning and growth [22-23]. These factors not only destroyed the breeding grounds but also caused havoc to the availability of brood fish including fry and fingerlings [23]. As a result, recently the fish is considered as one of the most endangered species in Bangladesh [24]. Rivers and surrounding land drained by catchments are very important for wildlife habitats. The quality of aquatic environment generally depends on four kinds of factors, such as physical, chemical, biological and meteorological factors [25]. Water Quality is controlled and determined by the combinations of all kinds of factors in various ways and intensities [26]. Just by assessing the physical, chemical and biological characteristics of water one can conclude about its quality [27].

1.2 Background of Research Topic

Bangladesh is an agro-based riverine country. There are a lot of rivers criss-crossed throughout the country. More or less 80% of our people depend on agriculture for their occupation and fisheries are one of the sub-sectors which play an important role in the socio-economic development of Bangladesh. Inland open water of this country mainly includes the network of rivers and canals, haors, beels (depression often with permanent area of water) and ponds. This environment is dependent on chemical status as well as water chemistry which lead the aquaculture more productive. It is said that about 700 (Seven Hundred) [28] Canals, Tributry, Distributry including small and big Lakes here in Bangladesh .Statics show that , about 230 flowing rivers exist here and the rest are silted up or turned into plain or cultivated land [29]. As a result the biovariety is on the treat of extinction and people living on fishing are suffering from job crisis. Many species of water animals have already been died out. The flowing rivers are on the face of maintaining ecological balance. The Vairab is the longest river of Khulna and Jessore. She originates from the river Jalangari of West Bengal, India [30] and runs through Meherpur, Chuadanga and some portion of the river enters again into India through Darshana border. Its length is 159 KM [31]. India has built a dam named as "Regulator or Cross dam" across the Vairab at Karimpur in Nadia district [32]. Through this Regulator India alone is using water of Jalangari. As a result the flow is extremely decreasing in down of the river 'Vairab' in Bangladesh. In dry season the rising point of Vairab gets emaciated, then the river flows very weakly and the water gets salty. Proper maintenance of rivers is very important not just because of their crucial role in maintaining ecological balance, but because the very existence and future development of this new delta are dependent on the river system [33]. In terms of quality, the surface water of the country is unprotected from untreated industrial effluents and municipal wastewater, runoff pollution from chemical fertilizers and pesticides, and oil and lube spillage in the coastal area from the operation of the river ports. Water quality also depends on effluent types and discharge quantity from different type of industries, types of agrochemicals used in agriculture, and seasonal water flow and dilution capability by the river system [34]. Vairab River has two main branches, the Khulna-Ichamati and the Kobadak. The Khulna-Ichamati forms a boundary between Bangladesh and India.

The towns of Khulna and Jessore are situated on the bank of the river [35]. The development of their settlements and culture were influenced by the river. Most of the industries and factories of Khulna are situated on the banks of the Vairab or very close to the river system without setting up waste treatment units during the past decade. The urban sewage of Khulna city is also thrown in the Vairab River, so, huge amount of effluents and solid wastes are adding with the river water. Besides these oil and oil wastes spills causing pollution in the Vairab water. A few works has been performed in relation to the pollution aspects to assess the environmental impact of the industrial effluents, agrochemicals, pesticides, untreated municipal wastes and trace metals of the Vairab River. Water quality study of Vairab River is important due to its geographical position. It can act as a pocket to carry the chemical load through Rupsha River and due to land use activities. Water quality scenario can be changed due to these sorts of actions.

1.3 Objective of the Study

i. Measurement of physico-chemical parameters such as temperature, turbidity, pH, chloride, hardness, DO, BOD, COD.

ii. Measurement of some fresh water elements such as Fe, As, Pb, Cd and Cr.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

Literature Review

For getting knowledge about water quality and its impact on aquatic environment of Vairab river number of local and foreign books and research articles in respect of water pollution by fresh water elements were collected and reviewed.

Islam *et al*. [36] carried out a study to evaluate the water quality in the Possur, Rupsha and Vairab river channel. In this study he stated that the temperature, DO, pH, were nearly to the standard levels, but the other parameters were not in the optimum range. In spite of some constrains most of the hydrographical parameters defining the quality of the surface water in the Vhairab-Rupsha-Possur river system were found to be within acceptable range except one or two. It is observed that hardness, alkalinity, chloride and salinity in the water gradually increased upstream to downstream.

A thesis paper on Buriganga River [37] from Jahangirnagar University stated that the physical parameter such as temperature were not within the safe limit. This may be due to the heated waste water released into the river from adjacent areas. All of the EC values were within the permissible limit during wet season. Chemical properties such as pH were higher at Dhaka Match but the average pH value was within the safe limit. All of the DO values were not within the safe limit. All of the BOD and COD values were much higher than permissible limit. Excessive amount of BOD and COD create an unfavorable environment for aquatic lives. The concentration of Iron of Buriganga River was high during wet season due to various industrial activities. The concentration of Copper at every location was within the allowable limit. The concentration of Chromium and Cadmium were recorded. All of the values were higher than the permissible limit during wet season. This may be due to the various industrial and urban activities. Lead was below detection level. This may be due dilution effect. From the observation of the comparison it was also visualized that the average concentration of Iron, Copper, Chromium and Cadmium in wet season were higher than the average concentration of Iron, Copper, Chromium and Cadmium in dry season.

Wahidatunnessa *et al*. [38] conducted a study on Gollamari River. During the study it was found that dissolved oxygen level was extremely low than the normal value of river water. Whereas alkalinity, free carbon dioxide, chloride, hardness values were extremely higher than normal range, which indicates that the water of Gollamari River is extremely polluted. As capture-based fisheries are practiced here, indiscriminant catching of fishes and frequent dumping of domestic, clinical and industrial waste and effluent, pollution occurred by surrounding inhabitants; it is becoming a death zone of fish and other aquatic organisms. Although no biological, chemical, ecological methods have been taken for improving the water quality of this river. The deterioration of the water of this river are mostly comes from direct or indirect human activities.

Alam *et al*. [39] conducted a study to evaluate the benefits of environmental improvement of river Buriganga. They applied the contingency value method (CVT) for estimating the benefits of the cleanup of polluted and degraded areas in developing countries. The traditional method, which was based on the "Western concept of willingness to pay", was being questioned in terms of its applicability for societies where the market mechanism was not fully developed. The new concept is tested with empirical information collected in 2001 through a survey of 400 households living around the dying river Buriganga in Dhaka Bangladesh. The people surveyed were given a scenario for the improvement of the ecological health of river using a variety of technological solutions and were asked what their willingness to contribute was. The major finding of testing this approach is that it gives a much better picture of the real value of environmental improvement.

Gupta *et al*. [40] stated that the DO and COD of Sitalakhy river were recorded at 4.5 and 20 ppm respectively.

Islam *et al*. [41] conducted a study on Dhaleshwari river. During the study it was observed that water temperature was found lower in the post-monsoon than that of monsoon and pre-monsoon season. In most cases, it was just above 30^0 C which was within the standard limit for uses of all purposes. The pH measured in the river revealed that the water was rather alkaline, i.e. pH was higher than 7.0 in the monsoon season. In the pre- and post-monsoon season, pH was much lower than 7.0. The transparency was found 9.5 to 35.5 cm during monsoon season. In post-monsoon the river water was so transparent that the transparency was incalculable and during pre-monsoon the river was almost dry except two stations with transparent water. The EC was ranged 136 to 267, 181 to 540, 288 to 411 μs/cm in monsoon, post-monsoon and pre-monsoon season, respectively. Due to seasonal variations, all sites showed lower EC value than the standard of 700 μs/cm. TDS is an important chemical parameter in water, mainly indicated the presences of various minerals including ammonia, nitrate, nitrite, phosphate, alkalis, some acids, sulphates, metallic ions, etc., which are comprised both colloidal and solids in water. The TDS concentrations were ranged 69 to 131, 95 to 299 and 190 to 224 ppm in monsoon, post-monsoon and pre-monsoon, respectively. TDS concentrations both in post- and pre-monsoon seasons were exceeded the standard limit of 165 ppm. It could be due to cut off the river bank for agriculture practices, cultivation in the river bed and along the bank area as well as use of fertilizers and pesticides, and river bank erosion [42]. A positive relation was found between EC and TDS where the EC value increased with increasing TDS concentration. The DO content was ranged from 4.9 to 9.0, 4.1 to 9.8 and 5.7 to 7.3 mg/L in monsoon, post-monsoon and pre-monsoon seasons, respectively which were favorable for fish and other aquatic organisms. The concentration of DO was higher in monsoon when compared with post and pre-monsoon season. The lower level was observed due to agricultural slurry, surface runoff of nutrients and enrichment by nutrients. When BOD level is high, DO level decrease because the oxygen available in the water is being consumed by the bacteria. Since less DO is available in the water, fish and other aquatic organisms may not survive. If there is no organic waste present in the water, there would not be as many bacteria present to decompose it and thus the BOD will tend to be lower and the DO level will tend to higher. Lower BOD values were found in Dhaleshwari River among three seasons which was suitable for fisheries production. The concentration of alkalinity was found to vary from 126 to 200, 150 to 595, 450 to 640 mg/L in monsoon, post-monsoon and pre-monsoon season, respectively. Post-monsoon showed more alkaline water than monsoon but comparatively less than pre-monsoon season. The river banks were widely used for agricultural practices and during pre-monsoon most of the crops are harvested. A total hardness of 50 mg/L is considered as the dividing line between hard water and soft water and 15 mg/L or more is suitable for fish culture [43]. All of the three seasons showed that the Dhaleshwari river water was suitable for fish culture because hardness of all sites were within the standard limit (123mg/L).

Rahman *et al.* [44] conducted a study on Passur river in the Sundarbans, the world's largest mangrove forest. Overall, the water quality parameters of the river were acceptable during rainy season. Result indicated that the concentration of TSS (10.8-19.7 g/L) during summer and TDS (3.5-53.3 g/L) in all the season exceeds the recommended concentration for Bangladesh. The highest DO concentration (6.0-7.33 mg/L) was observed in winter; nonetheless, the highest BOD (20.2-28.0 mg/L) was obtained in summer season. Moreover, in summer the river water showed high value of COD (19.0-38.0 mg/L). The alkalinity and hardness of river water was gradually increased in winter and summer season than that of the rainy season. Sea water intrusion and industrial discharge may contribute the high concentration of Cl^-(12.5-4672 mg/L), SO_4^{2-}(9.02-968.3 mg/L), HCO_3^- (116-203.3 mg/L), Mg^{2+} (4.86-583.2 mg/L), Na^+ (329-8839 mg/L) and K^+ (45.15-992.0 mg/L) ions. Through the year the measured average temperature, pH, EC, salinity of Passur river water were well matched with studies performed in this area and other regions.

Alam *et al.* [45] assessed the status of water quality of the Sitalaykhy river. Dissolved oxygen concentration of the Sitalakhya river from Tarabo to Siddirganj was found to be close to anoxic level due to huge amount of pollution load in these areas. Progressive increases in the dissolved oxygen concentrations measured in the upper portion of the Sitalakhya river. Higher concentration of Ammonia was observed during flood tide than ebb tide near Saidabad WTP intake. No significant variation in ammonia concentration with depth was observed. The 5-day Biochemical Oxygen Demand varied from 0.4 mg/L to 28.8 mg/L along the Sitalakhya river in dry season. The highest BOD was also found at Sarulia near Saidabad WTP intake in February and March 2009. Spatial and temporal variations of BOD were found similar to those of ammonia-nitrogen. Orthophosphate concentrations varied from 0.08 mg/L to 2.8 mg/L along Sitalakhy river. The water quality of this river is deteriorating rapidly, especially during dry season at certain reaches of the river and pollution has extended upstream gradually towards Ghorasal.

Sabbir *et al.* [46] performed a study on Mouri River, Khulna. The present study revealed that the mean values of water temperature, turbidity, TSS and TDS were 27.61^0C, 18.56 cm (secchi depth), 473.17 mg/L and 2560 mg/L respectively. Some aspects of the chemical parameters revealed that the mean ranges of pH, dissolved oxygen (DO), free CO_2, alkalinity, acidity, hardness, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and nitrite nitrogen were 5.5-9, 0.4-8.2 mg/L, 21-35.5 mg/L, 350-610 mg/L, 32.4-171.23 mg/L, 310-510 mg/L, 23-42.35 mg/L, 290-406 mg/L and 0.54-1.88 mg/L respectively. All the measured water quality parameters showed a greater deviation from the standard parameters and the water of the river is not suitable for most of the aquatic organisms. This river acts as main dumping site of Khulna city that is leading the river towards environmentally degraded condition. Hence it has become an imperative to take all necessary steps to reduce the status of pollution of this river.

Rahman *et al.* [47] conducted a study along the River Buriganga, Bangladesh. They observed that the river receives wastewater from numerous numbers of sources along its way, which are discharged as industrial effluents, municipal sewage, household wastes, clinical wastes and oils. The water samples were analyzed for various physicochemical quality parameters, which includes: temperature, pH, EC, DO, BOD, COD, PO_4-P, NH_3-N, Pb and Cr. The mean values for the parameters in both dry and wet seasons were compared with the surface water quality standards as set by the Department of Environment (DOE) in Bangladesh. The results from data analysis show that the Buriganga River water quality is not acceptable from aquatic ecosystem perspectives for the parameters such as DO, BOD, COD, NH_3-N and Cr during both dry and wet seasons and for EC during the dry season. On the other hand, the study concluded that the river water still acceptable in both dry and wet seasons in terms of parameters such as temperature, pH, PO_4-P and Pb. The overall mean values of parameters for the river Buriganga were temperature: dry-20.86^0C, wet-29.82^0C; pH: dry-7.41, wet-7.42; EC: dry-660.56, wet-82.6; DO: dry-0.85, wet-2.8; BOD: dry-34.5mg/L, wet-2.5; COD: dry-60.12, wet-17.2; PO_4-P; dry-0.53, wet-0.64; NH_3-N:

dry-4.12, wet-3.28; Pb: dry-0.006, wet-0.0008 and Cr: dry-0.056, wet-0.074. This study indicates that the water of the Buriganga River is being polluted from its surrounding point and non-point sources which include discharges from tannery industries, sewage and municipal wastewater.

Begum *et al.* [48] carried out a study to determine heavy metal contamination and chemical profile of Cauvery River water Analysis of water, plankton, fish and sediment reveals that the Cauvery River water in the downstream is polluted by certain heavy metals. Water samples have high carbonates. Concentrations of all elements and ions increase in the downstream. Main ions are in the following order: $Na^+ > HCO_3^- > Mg^{2+} > K^+ > Ca^{2+} > Cl^- > SO_4^{2-}$. Heavy metal concentration in water was Cr>Cu≈Mn>Co>Ni>Pb>Zn, in fish muscles Cr>Mn>Cu>Ni>Co>Pb≈Zn, in phytoplankton Co>Zn>Pb>Mn>Cr and in the sediments the heavy metal concentration was Co>Cr>Ni≈Cu>Mn>Zn>Pb. Although, the quality of Cauvery River may be classified as very good based on the salt and sodium for irrigation, Zn, Pb and Cr concentration exceeded the upper limit of standards. Metal concentrations in the downstream indicate an increase in the pollution load due to movement of fertilizers, agricultural ashes, industrial effluents and anthropogenic wastes. An immediate attention from the concerned authorities is required in order to protect the river from further pollution.

Shesterin et al. [49] conducted a study on water pollution and its impact on fish and aquatic invertebrates. They analyzed fish from the river Oka basin and revealed irregularity of metal distribution in fish organs. In all species except bream and white-eyed bream (*Abramis sapa*), copper was absent in the muscles, while in the liver of silver bream (*Blicca bjorkna*) its content exceeded the allowable amount by 1.3 times, and in the livers of bream, sabrefish, and white-eyed bream, this level was exceeded by a factor of 3.1, 5.5 and 17.8, respectively. Spwan of silver bream and white-eyed bream contained significant amounts of copper. Unlike organic substances which are all in due course degraded, adsorbed or assimilated in the water body, metal compounds retain their toxicity virtually indefinitely, since during their transformation the basic component of the compound, i.e. the metal, does not change. The toxicity of metal is determined by many factors including concentration and

CHAPTER 3

DESCRIPTION OF PHYSICO-CHEMICAL AND FRESH-WATER ELEMENTS PARAMETERS

CHAPTER 3

Description Of Physico-Chemical And Fresh-Water Elements Parameters

Physical parameter

3.1 Temperature

Temperature is one of the most important parameters in natural surface water systems. The temperature of surface waters governs to a large extent the biological species present and their rates of activity. Temperature has an effect on most chemical reactions that occur in natural water systems. Temperature also has pronounced effect on solubility of gases in water. A rise in temperature of water accelerates chemical reactions, reduces solubility of gases, amplifies taste and odor, and elevates metabolic activity of organisms [51]. The optimum temperature for irrigation water ranges from 20 to 30^0C [52].

3.2 Turbidity

Turbidity is opposite to clarity. It is a measure of how cloudy a water body is. Most people have seen how rivers turn brown after heavy rain. Turbidity is a measure of the extent to which light is either absorbed or scattered by suspended material in water. Most turbidity in surface waters results from the erosion of colloidal material such as clay, silt, rock fragments, and metal oxides from the soil. Construction areas, deforested areas and cropland have relatively high rates of erosion while forest and grassland have lower rates of erosion [53]. Vegetable fibers and microorganisms may also contribute to turbidity. The colloidal material associated with turbidity provides adsorption sites for chemicals that may be harmful of cause undesirable tastes and odors and for biological organisms that may be harmful [54]. In natural water bodies, turbidity may impart a brown or other color to water, depending on the light-absorbing properties of the solids, and may interfere with light penetration and photosynthetic reactions in streams. Accumulation of turbidity-causing particles in porous streambeds results in sediment deposits that can adversely affect the flora and fauna of the stream. Turbidity measurements are normally made on "clean" waters as opposed to wastewaters. Natural waters may have turbidities ranging from a few NTUs to several hundred. EPA drinking-water standards specify a maximum of 1 NTU, while the American Water Works Association has 0.1 NTU as its goal for drinking water [55]. Soil particles carried by runoff cause this to happen. When the water is turbid, floating particles absorb heat from the sun and cause the water temperature to rise. Higher temperatures cause oxygen levels in the water to fall, limiting the ability of fish and insects to survive there. Another effect is that the floating particles may clog fish gills. When these particles sink, they can smother and kill fish and aquatic insect eggs that lay on the bottom. Turbidity can also limit plant growth. This happens when sunlight cannot reach the plants' leaves. The combination of warmer water, less light and oxygen depletion makes it impossible for some forms of aquatic life to survive.

Turbidities of 10 NTU or less represent very clear waters; 50 NTU is cloudy; and 100-500 or greater is very cloudy to muddy [56]. Some fish species may become stressed at prolonged exposures of 25 NTUs or greater. Furthermore, Barners [57] recommended that to maintain native fish populations in Georgia Piedmont Rivers and streams, those random monthly values should never exceed 100 NTU.

Chemical parameter

3.3 pH

pH is a measure of acidity or alkalinity on a scale from 0-14, with low numbers being more acidic and 7 being neutral. Exposure to low or high pH may cause death or reproductive problems for fish and other aquatic life. The tolerable range of this parameter is between 6 and 8.5 [58]. The survival of aquatic organisms is also greatly influenced by pH of water bodies because most of their metabolic activities are pH dependent [59].

pH is defined as the negative log (base 10) of hydrogen ion concentration and is unit less, i.e.

$$pH = -\log[H^+]$$

The pH of most mineral water is 6 to 9 [60]. The pH remains reasonably constant unless the water quality changes due to natural or anthropogenic influences, adding acidity or basicity. As most ecological life forms are sensitive to pH changes, it is important that the anthropogenic impact (e.g. effluent discharges) be minimized. Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment, e.g., acid-base neutralization, water softening, precipitation, coagulation, disinfection and corrosion control is pH dependent [61]. Below pH 6.5 species experiences slow growth [62]. At approximately pH 4 or below and pH 11 or above most species die [63].

3.4 Hardness

Total hardness is a measure of the concentration of all metal cations with the exception of the alkali metals in solution. At supersaturated conditions, the hardness cations will react with anions in the water to form a solid precipitate. Hardness is classified as carbonate hardness and noncarbonated hardness, depending upon the anion with which it associates. The multivalent metallic ions most abundant in natural waters are calcium and magnesium. To a much lesser extent, hardness also includes other divalent ions such as iron (Fe^{2+}) and (Ba^{2+}). Water is classified with respect to its hardness and softness. These categories were originally developed for municipal water treatment and thus have no biological relevance [64]. Calcium is the most important component of hardness to aquaculture. It is necessary for bone and exoskeleton formation and osmoregulation. Crustaceans absorb calcium from the water when molting and if the water is too soft their exoskeletons begin to soften and they may cease to molt. In addition, bone deformities and reduced growth rates may result if water is too soft. Hardness also affects aquaculture species and operations through its chemical interactions with other species in water. Calcium reduces the toxicity of metals, ammonia and the hydrogen ion. In addition, due to the higher on concentration in hard waters, suspended soil particles settle faster in hard water than soft water. For waters where alkalinity is high and calcium is low, photosynthesis may increase the pH to levels that are toxic to fish [65].

3.5 Chloride

Chloride ions in the environment can come from sodium chloride or from other chloride salts such as potassium chloride, calcium chloride and magnesium chloride. Chloride concentration in water indicates the presence of organic waste in water, primarily of animal origin [66]. It increases with ammonical nitrogen which also owes itself mostly to animal excreta. More chlorides are entering groundwater through human waste. Sodium chloride is added to many processed foods to delay spoilage while bringing out flavor. However, chlorides are not removed from waste by septic tank treatment processes and enter the leach field with the rest of the effluent, or wastewater. From there, chlorides can enter groundwater through septic systems and find their way into lakes, ponds, streams, and rivers. A third anthropogenic source of chlorides in groundwater is fertilizer made with potash, or mined salts. Potassium chloride is salt most commonly used in potash fertilizer, and potassium (K on fertilizer bags is one of three essential nutrients along with N – nitrogen and P – phosphorous) that are added to increase soil fertility on farms and phosphorous, chloride can leach from fertilized soils into rivers and streams. Excessive chloride ions cause's two main types of damage: corrosion of water pipes, which leaches harmful agents into drinking water, and agricultural harm, as salt concentrations higher than 150 ppm considerably reduce plant grow.

Chlorides are one of the major constituents found in all natural waters in different concentrations. Human excrete and industrial wastes etc. are rich in chlorides. For public health, chlorides up to 250 mg/L are not harmful but increases of chlorides beyond this are indication of organic pollution [67]. Chloride is a strong oxidizing agent and liberates iodine from potassium iodide. Chloride ions are conservative, which means that they are not degraded in the environment and tend to remain in solution, once dissolved. Chloride ions that enter ground water can ultimately be expected to reach surface water and, therefore, influence aquatic environments and humans. Among the species tested, freshwater aquatic plants and freshwater growth. For dissolved oxygen concentrations approximately 1-5 mg/L the dissolved oxygen is still high enough for survival however, long-term exposure results in slow growth. As dissolved oxygen gets below 1mg/L, it becomes first lethal after long term exposure and at lower dissolved oxygen, only small fish can survive short-term exposure [73].

3.7 Biological Oxygen Demand (BOD)

Biological oxygen demand (BOD) is defined as the amount of oxygen required by microorganisms to stabilize biologically decomposable organic matter in a waste under aerobic condition. It is an approximate measure of the amount of biochemically organic matter present in the sample. More the oxidizable organic matter present in water, more the amount of oxygen required to degrade it biologically, hence more the biological oxygen demand [74]. Natural organic detritus and organic waste from waste water treatment plants, failing septic systems, and agricultural and urban runoff, acts as a food source for water-borne bacteria. Bacteria decompose these organic materials using dissolved oxygen, thus reducing the DO present for fish and other aquatic livings. Biochemical oxygen demand (BOD) is a measure of the amount of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. This parameter is used to measure the level of water pollution, especially those arising from organic wastes such as from the agricultural development. High amounts of BOD are associated with river water pollution that is high [75-80].

The major concern of BOD is the potential for it to deplete oxygen to levels which are dangerous to fish. If source water contains a large amount of BOD, microbial growth will be enhanced especially at high temperature [81]. With this microbial growth and the corresponding degradation of organic matter oxygen will be consumed. This can lead to the depletion of oxygen in the river and its associated effects on fish and other aquatic organisms including death. Under some circumstances, microbial metabolism can consume dissolved oxygen faster than atmospheric oxygen can dissolve into water or the autotrophic community (algae, cyanobacteria and macrophytes) can produce. Fish and aquatic insects may die when oxygen is depleted by microbial metabolism [82]. Dissolved oxygen depletion is most likely to become evident during the initial aquatic microbial population explosion in response to a large amount of organic material. If the microbial population deoxygenates the water, however, that lack of oxygen imposes a limit on population growth of aerobic aquatic microbial organisms resulting in a longer term food surplus and oxygen deficit [83].

3.8 Chemical Oxygen Demand (COD)

The COD parameter has connection to the BOD parameter in which the oxygen reaction for the decomposition process of organic materials chemically needs to be monitored. Increase in COD readings in excess of the standard shows the presence of organic pollutants in the water bodies and thus, the oxygen required is also of a huge amount. An abundance of these organic pollutants directly causes lack of oxygen in the water and thus, living things in the water cannot get sufficient oxygen. The standard used by the DE for classification of clean for COD should not exceed 50 mg/L for Class III [75].

The COD test measures the total organic carbon, with the exception of some aromatics such as benzene which are not oxidized in the reaction. The test determines the amount of oxygen needed to chemically oxidize the organics in a water or wastewater. It is described in detail in Standard Method [84]. A strong chemical oxidizing agent is used to oxidized the organics rather than using micro-organisms as in the BOD test. The oxidizing agent is potassium permanganate in an acid solution. COD is attractive as a test since it takes about 2 hours by comparison with 5 days for the BOD. A disadvantage is that it tells us nothing about the rates of biodegradation.

Commonly, COD is used to define the strength of industrial wastewaters that either are not readily biodegradable or contain compounds that inhibit biological activity. Frequently, laboratory wastewater treatability studies are based on COD testing rather than on BOD analysis. The COD test has the advantages of rapid analysis and reproducible results. The BOD test requires incubation for five days, and the results of multiple analyses on an industrial wastewater sample often show considerable scatter. Also, COD testing is becoming more popular in all applications of oxygen demand analyses as a result of simplified laboratory techniques. The COD method is recommended as a supplement to BOD test. The COD test is widely employed as means of measuring of pollution strength of domestic and industrial wastes [85].

Fresh water Elements

Usually fresh water elements occur in almost all water supplies but at very low concentrations, usually less than a few mg 1, not all fresh elements are toxic and in small quantities many are essential for plant growth. However, excessive quantities will cause undesirable accumulations in plant tissue and growth reductions and when one is exposed to high concentrations; it can cause health problems [86].

3.9 Iron (Fe)

Small amounts of iron frequently are present in water because of the large amount of iron in the geologic materials. The presence of iron in water is considered objectionable because it imparts a brownish color to laundered goods and affects the taste of beverages such as tea and coffee [87]. Iron concentrations of 0.3mg/L can cause color problems. Additionally some bacteria use iron compounds for an energy source, and resulting slime growth may produce taste and problems [88]. When significant quantities of iron are encountered in natural water systems, it is usually associated with chloride ($FeCl_2$), bicarbonate [$Fe(HCO_3)_2$], or sulfate [$Fe(SO_4)$] anions and exists in a reduced state. In the presence of oxygen, the ferrous (Fe^{2+}) ion is oxidized to the ferric (Fe^{3+}) ion and forms an insoluble compound with hydroxide [$Fe(OH)_3$]. The precipitate can then have deleterious effects upon the operation. Common sources of ferric iron are bottoms of large reservoirs during summer and deep ground water [89]. The metals get into the tissues of aquatic animals mainly via their food. In fish, metals can also come via mechanical capture of suspended particles of hydroxides in gills and chemical absorption of ions on the mucous membrane. Iron is a major element in soil. Iron occurs primarily as a free ferrous form, iron (II) in acidic water ($pH < 5.8$) when the water oxygen concentration is low [90]. This iron form is deleterious to fish [91-93]. Newly-hatched rainbow trout (*Oncorhynnchus mykiss*) died in an iron(II) concentration of 1.3 mgl^{-1} (pH 6-8) [93]. Oxidized iron is deposited on eggs and gills whereupon the diffusion of gases becomes more difficult [94-101]. The ingestion of large quantities of iron can damage blood vessels, cause bloody vomits/ stool, and damage the liver and kidneys, and even cause death. However, because ingestion is regulated, body tissues are generally not exposed to high-level concentrations. Again iron is an essential nutrient for good health. It is a major component of hemoglobin, which is used to transport oxygen and carbon dioxide in the blood. Iron deficiency can enhance lead absorption and toxicity; anyone with increased blood lead levels should be tested for iron deficiency.

3.10 Lead (Pb)

Exposure of the body to lead, however brief, can be seriously damaging to health. Prolonged exposure to relatively small quantities may result in serious illness of death. Lead taken into the body in quantities in excess of certain relatively low "normal" limit is a cumulative poison. Lead toxicity is due to concentration of diffusible Pb in soft tissues. Another possible mechanism for Pb toxicity is due to formation of metallothionein. Dissolved lead concentrations in the environment are generally low due to either precipitation of carbonate species or adsorption to particulate matter [102]. There is some evidence that lead forms organometallic compounds in natural systems which can accumulate in fish [103-104]. The backgrounds levels of dissolved lead in surface waters rarely exceed 20 ppb [105].
Chronic lead toxicity in aquatic organisms leads to nervous system damage while acute toxicity causes gill damage and suffocation [106]. The solubility of lead and its toxicity is lower in hard waters than in soft waters [107]. For the same reason, lead toxicity is higher at lower pH levels which would be common particularly at rivers bottom and among benthos and nutrients [108].

3.11 Arsenic (As)

Arsenic occurs naturally in the environment, and it is also widely used in timber treatment, agricultural chemicals (pesticides), and manufacturing of gallium arsenide wafers, glass, and alloys. Arsenic in drinking water is associated with lung and urinary bladder cancer. Arsenic is a naturally occurring ubiquitous element with metalloid properties. Arsenic and its compound are well known for its toxicity and carcinogenicity. Bangladesh, India, China, Taiwan, Thailand, Chili, Romania are the major affected countries where inorganic arsenic present in the ground water with high concentration. The areas across the Gangetic plains in India and Nepal also recently reported as the area affected from it [109]. WHO and EPA had set up the standard for drinking water known as MCL which is 10 μg/L. Drinking water with

MCL or below to MCL is not hazardous to the population. Long-term ingestion of inorganic arsenic other than organic arsenic causes multisystem adverse health effects because organic forms are less toxic and rapidly excreted from body via urine. The clinical manifestations of chronic arsenic exposure are skin lesions, cardiovascular disease, neurological effects, chronic lung disease, cerebrovascular disease, reproductive disease, adverse renal affects, developmental abnormalities, hematological disorders, diabetes mellitus and cancers of skin, lung, liver, kidney and bladder. Low birth weight and adverse pregnancy outcomes are also documented by chronic toxicity of arsenic. Skin manifestation is the early feature of chronic arsenic exposure and cancer is the late phenomenon.

3.12 Chromium (Cr)

Any Chromium compound is toxic but hexavalent Cr greater than 70 mg is very toxic. Health effects related to hexavalent Chromium exposure include diarrhoea, stomach and intestinal bleeding, cramps and liver and kidney damage [110]. It causes cancer, anuria, nephritis, gastrointestinal ulceration, perforation in partition of nose. It penetrates cell membrane and badly affects central nervous system. Causes respiratory trouble, lung tumors when inhaled. May cause complications during pregnancy. Have adverse effects on aquatic life. Trace amount of Cr (III) is essential for normal glucose, protein and fat metabolism and hence it is a essential trace element in diet.

Chromium used in industries in the manufacture of steels, jet engines, tools, paints, photography, electric cells, rubber goods and matches. Chromium bound to β-globulins is distributed in lungs, heart, brain, liver, tests and spleen. Trivalent Cr is least toxic of trace elements while hexavalent Cr (greater than 70 mg) is very toxic. It causes cancer, anuria, nephritis, gastro intestinal ulceration and affects central nervous system. It is present in soils and plants at 1-2.5 ppb in sea water and about 200 ppm in earth's crust. A human body contains 6 mg Cr. It accumulates in lungs with age. In natural waters chromium typically has concentrations less than 5 ppb and rarely get above 20 ppb [111]. The United Nations Food and agriculture Organization recommended maximum level for irrigation waters is 100 μg/L. The U.S. EPA primary drinking water standard MCL is 0.1 mg/L for total chromium.

3.13 Cadmium (Cd)

Cadmium is generally classified as toxic trace element. It has specific uses in paint and nickel-cadmium batteries. Geologic deposits of cadmium can serve as sources to groundwater and surface water, especially when in contact with soft, acidic waters. Webb (1979) [112] reported that geochemical implications of Cd in human health are related to (a) bone and renal disease in populations exposed to industrially contaminated drinking water, (b) lung and renal dysfunction in industrial workers exposed to air-borne Cd and (c) implication in human hyper-tension. It has been documented that the kidney is the main organ affected by chronic Cd exposure and toxicity [113-114]. The kidney is considered to be critical target organ in humans chronically exposed to cadmium by ingestion [115]. Cadmium replaces zinc in the body, and long-term consumption of cadmium may lead to bodily disorders.Cadmium is toxic to all men and animals. Cd toxicity (50 mg) causes vomiting, diarrhea, abdominal pains and loss of consciousness. It is also causes growth retardation, bone deformation, impaired kidney functioning, impaired reproductive function, hypertension, tumor formation and teratogenic effects. If we inhale Cd through nose, it causes choking, coughing, bronchitis and damage to renal tissues. Acute toxic exposure of fish damages the central nervous system and parenchymatous organs. Chronic exposure adversely affects the reproductive organs of aquatic organisms, as well as maturation, hatchability and development of larvae [116-117]. Most of cadmium which binds with solid particles ends up in sediments where its biological availability is limited and thus less toxic. Calcium also reduces the toxicity of dissolved cadmium, so it is somewhat less toxic in hard water [118]. According to BDS the acceptable limit of Cd is 0.005 mg/L.

CHAPTER 4

MATERIALS

AND

METHODS

CHAPTER 4

Materials And Methods

4.1 Study plan

Following flow chart shows the study plan

LITERATURE RIVEW
↓
SITE SELECTION
↓
SAMPLE COLLECTION
↓
SAMPLE PREPARATION
↓
SAMPLE ANALYSIS
↓
DATA ANALYSIS
↓
REPORT ANALYSIS

4.2 Location of the Study area and Period

The study area of Vairab river channel from Nowapara, Jessore to Labonchara, Khulna is located in the southwest of Bangladesh and the longitude of the study area 89^{0}23’41.6” to 89^{0}34’58.9” East and latitude of the study area 23^{0}02’12.6” to 22^{0}46’42.0” North. Khulna City area is bounded by the river of Vairab on the northeast, Rupsha on the southeast. The Atharobanki river meets with Rupsha and Atai river meets with Vairab river on the central east [119]. These rivers are virtually the distributaries of Ganges River, which carry sediment from upstream. The Rupsha-

Vairab river are the active tidal river with strong current. The study was carried out during the period 13 July,2013 to 23 October,2013.

4.3 Site Selection and Sample Collection

Samples were collected from four locations of Vairab River. Water sampling was started from the point, 23^{0}02’12.6”N and 89^{0}23’41.6”E (Shankar Pasha Ferry ghat, Nowapara) and finished at the point, 22^{0}46’42” and 89^{0}34’58.9” (Labonchara, Rupsa Bridge, Khulna). The total distance 'from Shankar Pasha Ferry ghat, Noapara to Labonchara, Rupsa Bridge, Khulna was 50 kilometers. Water samples were collected at each point at a depth of one foot to avoid interference of the floating substances. 2.5L plastic bottles and 100ml DO bottles were used for sample collection and preservation.

4.4 Preparation of Sampling Bottle

- Sample bottles were rinsed properly with the samples to avoid dilution and interferences.
- Sample bottles were tightly sealed and there no air bubbles in the sample bottles after sampling.
- Samples bottles were tagged with specific sample code.
- All the collected samples were placed into a plastic box and transported to the chemistry laboratory immediately for further analysis.

4.5 Preservation of Samples

The preservation procedure varies depending of the test to be performed. The sample for DO and BOD, after collection should not be allowed to remain in contact with the air or be agitated because either condition causes a change in its gaseous content. The DO sample should be fixed on the spot by some prescribed reagents (such as, Manganese Sulphate $MnSO_4.4H_2O$ and Alkali Iodide Azide) as soon as the samples has been collected [120].

Water samples were quickly brought into the laboratory and initially 500ml were filtered with Whatman-44, Ash less, 125mm diameter filter paper and then acidified by concentrated HNO_3 acid (4ml/Liter) to prevent adsorption of metal ions on the sides of the bottles. Finally bottles covered with cap and stored at refrigerator.

4.6 Data collection and GIS Analysis

Latitude and longitude position of each location from where samples were collected was confirmed by GPS (Model: Xplora GPS 200) reading which is given in Table (4.1):

Table 4.1: Location, Latitude, Longitude & sample ID of the sampling points

Sl. No.	Location	Latitude	Longitude	Sample ID
1	Shankar pasha Ferry ghat, Nowapara, Jessore	$23^0$02’12.6”N	$89^0$23’41.6”E	V-1
2	Akij Leather, Nowapara, Jessore	$23^0$01’02.9”N	$89^0$24’43.0”E	V-2
3	Kali bari ghat, Khulna	$22^0$49’06.5”N	$89^0$34’18.5”E	V-3
4	Labonchara, Rupsha Bridge, Khulna	$22^0$46’42.0”N	$89^0$34’58.9”E	V-4

Table 4.2: Parameters that are studied

Physical Parameter	Chemical Parameter	Fresh Water Elements
Temperature	pH	Iron(Fe)
	Hardness	Lead(Pb)
	Chloride	Arsenic(As)
Turbidity	Dissolved Oxygen(DO)	Chromium(Cr)
	Biological Oxygen Demand(BOD)	Cadmium(Cd)
	Chemical Oxygen Demand(COD)	

Table 4.3 : Standard for drinking water

Sl. No.	Parameter	Units	Standards
1.	BOD at 20^0C	mg/L	0.2
2.	Cadmium	mg/L	0.005
3.	Chromium(6)	mg/L	0.05
4.	Chromium (total)	mg/L	0.05
5.	COD	mg/L	4
6.	Copper	mg/L	1
7.	DO	mg/L	6
8.	Iron	mg/L	0.3-1
9.	Lead	mg/L	0.05
10.	Nickel	mg/L	10
11.	pH	mg/L	6.5-8.5
12.	Zinc	mg/L	5
13.	Temperature	^0C	20-30
14.	Aluminium	mg/L	0.2
15.	Total dissolved solids	mg/L	1000
16.	Color	Hazen unit	15
17.	Boron	mg/L	1
18.	Mercury	mg/L	0.001
19.	Nitrate	mg/L	10
20.	Potassium	mg/L	12

Source : Guide to the Environmental Conversation Act 1995 and Rules 1997

Table 4.4 : Standard for inland surface

Best Practice based classification	Parameter			
	pH	BOD mg/L	DO mg/L	Total Coliform number/100
1. Source of drinking water for supply only after disinfecting	6.5-8.5	2 or less	6 or above	50 or less
2. Water usable	6.5-8.5	3 or less	5 or above	200 or less
3. Source of Drinking water for supply after	6.5-8.5	6 or less	6 or above	5000 or less
4. Water usable by fisheries	6.5-8.5	6 or less	5 or above	5000 or less
5. Water usable for various processes such as cooling industries	6.5-8.5	10 or less	5 or above	1000 or less
6. Water usable for irrigation	6.5-8.5	10 or less	5 or above	

Source : Guide to the Environmental Conversation Act 1995 and Rules 1997

Fig. 4.1: Municipal sewage from Nowapara Pourashava, Jessore

Fig 4.2: Salt Industry at Jail Gate, Khulna

Fig 4.3: Cement factory at Rupsha Ghat, Khulna

Fig 4.4: Municipal sewage at Kalibari Ghat, Khulna

Fig 4.5: Salt factory at Kalibari Ghat, Khulna

Fig 4.6: Industrial effluent from Akij leather factory at Nowapara, Jessore

Fig 4.7: Sea food processing industry at Rupsha Bridge, Khulna

Fig 4.8: Rice processing factory at Rupsha Bridge, Khulna

Determination of Physical Parameter

The methods applied for measuring physical parameter, such as temperature, electrical conductivity, salinity of selected water body are described below;

4.7 Temperature

The temperature was taken by a mercury thermometer graduated 0^0C to 100^0C. Water sample was taken in a clean beaker and bulb of the thermometer was dipped into the water for one minute. The value was noted and it was the water temperature.

4.8 Turbidity

The turbidity was measured by HACH portable spectrophotometer

Fig 4.9: HACH DR/2010, UV-Visible portable spectrophotometer

4.9 pH

Fig 4.10 : TOA pH meter HM-12P

The pH of water was determined by using a glass electrode pH meter (TOA pH meter HM-12P). The instrument was standardized at pH 4.7 & 10 with standard buffer solution (HACH singled pH buffer solution packs). After successful calibration electrode was rinsed thoroughly by using distilled water. The electrode was placed into the sample and readbutton was then pressed. When the reading was stable the pH was recorded.

4.10 Total Hardness

Hardness of water sample was measured by the standard method of APHA, 2005 [121].

4.11 Chloride

Method: Mohr's.

Apparatus:

i. Pipette
ii. Burette
iii. Micro pipette
iv. Conical flask

Reagents:

i. Silver nitrate
ii. Potassium chromate
iii. Sodium chloride

Procedure: 50ml water sample was taken in 250ml conical flask. Then 2 drops of K_2CrO_4 indicator solution was added into the flask. The sample solution was titrated with 0.1 N $AgNO_3$ solutions. At the end point color would be changed from yellow to pinkish yellow. For blank sample analysis 50ml distilled water was taken in 250ml Erlenmeyer flask and 2 drops of K_2CrO_4 solution was added into the flask and titrated with 0.1N $AgNO_3$ solution. For standardization of 0.1N $AgNO_3$ 10ml of 0.1N NaCl solution was taken in 250ml Erlenmeyer flask and 2 drops of K_2CrO_4 indicator solution was added into flask, then titrated with 0.1N $AgNO_3$ solution.

Concentration of Chloride ion (mg/L) = $\frac{(A-B)\times N \times 35450}{V}$

Where,

A= Volume of 0.1N $AgNO_3$ is required for titration (ml).

B= Volume of 0.1N $AgNO_3$ is required for blank titration (ml).

N= Concentration of $AgNO_3$ (N).

V= Volume of sample (ml).

4.12 Dissolved Oxygen (DO)

Fig 4.11: Titration for DO

Method: Winker titration

Apparatus:

1. DO bottle.
2. Burette.
3. Micro pipette.
4. Conical flask.

Reagents:

1. Manganese sulfate ($MnSO_4$)
2. Potassium iodide (KI)
3. Sodium Azide (NaN_3)
4. Sodium Hydroxide (NaOH)
5. Sulfuric acid (H_2SO_4)
6. Sodium thiosulphate ($Na_2S_2O_3$)
7. Starch indicator

Procedure: Water sample was collected in 100ml DO bottle, 1ml of Manganese sulfate & 1ml of alkyl iodide-azide solution was added to the sample. Then the stopper caped without any bubbles. The DO bottle shaked well and allowed the precipitate to settle & then 1ml of conc. Sulfuric acid was added to dissolve the precipitate. The liberated iodine was then titrated with 0.025N sodium thiosulfate solution.

$$\text{DO (mg/L)} = \frac{a \times f \times 1000 \times 0.2}{(V-2)}$$

a = Volume of solid thiosulfate.

f = Dilution factor

V = Volume of sample

4.13 Biochemical Oxygen Demand (BOD)

Method : DO probe -5 days incubation

Apparatus :

i. DO glass bottle (100ml)
ii. Measuring cylinder (100ml – 500ml)
iii. Pipette and Micro Pipette (1ml)
iv. Dilution machine
v. Reagent bottle (300ml)
vi. Volumetric flask (100ml – 2500ml)
vii. Beaker (500ml – 5000ml)
viii. BOD incubator at 20^0C
ix. Aerator
x. Shaker Machine
xi. Water bath with thermometer
xii. Bottle washing machine
xiii. pH meter

Reagents :

i. Di-potassium hydrogen Phosphate
ii. Potassium di-hydrogen phosphate
iii. Ferric chloride
iv. Sodium thiosulfate
v. Ultra-pure DI water
vi. Hydrochloric acid (1N and 0.1N)
vii. Sodium hydroxide (1N and 0.1N)
viii. Di-Sodium hydrogen phosphate
ix. Calcium chloride
x. Magnesium sulfate
xi. Sodium sulfate
xii. Glucose-glutamic acid

Procedure: For preparing dilution water, distilled water was taken in a glass beaker and aerated by organic free fresh compressed air for sufficient time to attain DO saturation at 20^0C. 1ml of each phosphate buffer, magnesium sulfate, calcium chloride and ferric chloride solutions were added for each liter of dilution water and mixed well. Quality of dilution water BOD was checked by blank sample at 20^0C for 5days incubation. DO uptakes of dilution water should not be exceed 0.20 mg/L.

The sample temperature was controlled at 20^0C. Sample was put on shaker for shaking about 10 minutes. The pH of sample should be kept within range from 6.95 to 7.20. For removing chlorine sodium thiosulfate was added. For residual chlorine containing water sample aeration was performed by aerator for saturation (2 hours). Transparency was measured and arranged all sample according to ID No. Dilution factor was selected according to transparency concentration. 100ml dilution water was taken in two DO bottles for blank analysis. The sample was diluted with dilution water avoiding bubble. Both samples were taken in BOD bottle and set up in BOD incubator at 20^0C for 5-days incubation. After 15 minutes incubation (same sample in BOD bottle), DO was measured at 20^0C by Winker titration method. After 5-days incubation this sample was measured the amount of dissolved oxygen by Winker titration method. Then BOD was calculated from 1st day and 5th day measurement data of DO concentration.

Calculation:

$$\text{BOD (mg/L)} = \frac{(D1-D2)}{P}$$

D_1 = DO conc. Of 1st day analysis (mg/L).

D_2= DO conc. Of 5th day analysis (mg/L).

P = % of dilution.

4.14 Chemical oxygen demand (COD)

Method: Permanganate Titration at 100^0C

Apparatus:

i. DO glass bottle (100ml)
ii. Glass beaker (500ml)
iii. Measuring cylinder (100ml)
iv. Micro Pipette (1ml)
v. Burette (20ml)
vi. Reagent bottle (300ml)
vii. Volumetric flask (100ml-250ml)
viii. Conical flask (300ml)
ix. Water bath

Reagents:

i. Silver nitrate
ii. Concentrated sulfuric acid
iii. Potassium permanganate
iv. Sodium oxalate

Procedure: 100ml water sample was taken in 300ml Erlenmeyer flask. 5ml silver nitrate solution and 10ml (1+2) sulfuric acid were added in the water sample and shaked well. White precipitate would be formed if chloride ion present in sample. In this case solution was heated on magnetic starrier. 10ml potassium permanganate solution was added and shaked well. Violate color would be developed. Then the solution was heated on water bath at 100^0C until this solution permanganate color would be disappeared (30 minutes). After heating 10ml sodium oxalate was added and cooled this solution at room temperature. This sample was titrated by potassium permanganate at 60^0C. Data was recorded. According to same procedure blank sample was measured and data was recorded. 25ml potassium iodate solution was taken in 300ml Erlenmeyer flask. 75ml distilled water and 10ml (1+2) sulfuric acid were added to flask and warmed at 30^0C. 22ml potassium permanganate was added from burette and shaked well. The solution was allowed to stand until red color disappeared. Then the solution was warmed at 60^0C on water bath and titrated it with potassium permanganate. End point color would be colorless to light pink. Data was recorded. From this data dilution factor of potassium permanganate was calculated.

$$\text{Dilution factor of } KMnO_4, f = \frac{a \times b \times 25}{100 \times 250 \times V \times 0.001675}$$

a = Weight of sodium oxalate (g)

b = Purity of sodium oxalate (%)

f = Dilution factor

V = Volume of Potassium permanganate required for titration (ml)

$$\text{Calculation: } COD_{Mn} \text{ (mg/L)} = \frac{(a-b) \times f \times 1000 \times 0.2}{V}$$

a = Volume of potassium permanganate for sample titration (ml)

b = Volume of potassium permanganate for blank titration (ml)

f = Dilution factor

V = Volume of sample

4.15 Determination of Fresh Water Elements

Fig 4.12 : Absorption Spectrophotometer (AAS) Model AA-7000

Analysis of Samples by Atomic Absorption Spectrophotometer (AAS)

Atomic absorption spectrometry is a latest, modern and generally accepted method for the analysis of many fresh water elements. In a typical AAS method, sample is aspirated into a flame, where ions within the liquid are reduced to the atomic state. The elements in the atomic state can then quantitatively absorb light at the wavelengths characteristic of their resonance frequencies, e.g. 217.0 and 283.3 nm for lead. Alternatively the ions may either be chemically reduced by a cold vapor technique or be thermally reduced in a graphite furnace before analysis. AAS method usually gives better sensitivities (as low as 50 μg/kg) than any other method such as Calorimetric.

By this method several hundred samples can be analyzed within a workday if the samples are already prepared, so it is a time saving method. In flame technique and cold vapor techniques, the sample must be in solution. Atomic absorption spectrophotometric analysis has been used in the present study for determination of fresh water elements in DPHE, Jhenaidah.

Principle of Atomic Absorption Spectrophotometer (AAS)

If a solution containing a metallic salt or some other metallic compound is aspirated into a flame (e.g. of acetylene burning in air), a vapor, which contains atoms of the metal, may be formed. Some of these gaseous metal atoms may be raised to an energy level, which is sufficiently high to permit the emission of radiation characteristic of the metal, e.g. the characteristic yellow color imparted to flames by compounds of sodium. However, a much larger number of the gaseous metal atoms will normally remain in an unexcited state or in other words, in the ground state. These ground state atoms are capable of absorbing radiant energy of their own specific resonance wavelength, which in general is the wavelength of the radiation that the atoms would emit if excited from the ground state. Hence if light of the resonance wavelength is passed through a flame containing the atoms in question, the part of the light will be absorbed and the extent of absorption will be proportional to the number of ground state atoms present in the flame. At the same time there is a reduction in the intensity of light beam, which can be measured and correlated with the concentration of the element atomic species. This is carried out by comparing the light absorbance of the unknown sample with the light absorbance of known calibration standards; this is the underlying principle of atomic absorption spectroscopy (AAS).

The most common form of atomic absorption spectroscopy is called flame atomic absorption. In this technique, a solution of the element of interest is drawn through a flame in order to generate the element in its atomic form. At the same time, light from a hollow cathode lamp is passed through the flame and atomic absorption occurs. The flame temperature can be varied.

By using different fuel and oxidant combinations; for example, a hotter flame is required for those elements, which resist atomization by tending to form refractory oxides.

The procedure by which gaseous metal atoms are produced in the flame may be summarized as follows. When a solution containing a suitable compound of the metal to be investigated is aspirated into a flame, the following events occur in rapid succession.

- Evaporation of solvent leaving a solid residue.
- Vaporization of the solid with dissociation into its constituent atoms, which initially will be in the ground state and
- Some atoms may be excited by the thermal energy of the flame to higher energy levels and attain a condition in which they radiate energy.

Water sample Preparation for Atomic Absorption Spectrometer (AAS)

All of the samples were analyzed directly by Atomic Absorption Spectrophotometer

Calculation of concentration

Concentration of elements were determined by AAS × Dilution factor = mg/L
In this calculation dilution factor = 1

Quality Control

Some quality control measures were followed carefully to avoid errors in the analysis. During sample preparation, the apparatus were washed and rinsed three times with distilled water. Rinsing the pipette and volumetric flask with the sample to be measured has been done to avoid interference and uncontrolled dilution.

During analysis, method blank and spiked duplicates were used to monitor analysis performance and acceptability. Checking the unknown standard solution after completion of a batch was performed as a measure of quality control.

CHAPTER 5

RESULT AND DISCUSSION

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Table 5.1: Result of water quality parameters at various locations in different months

Parameters	Unit	Location															
		V-1				V-2				V-3				V-4			
		July-13	August-13	September-13	October-13	July-13	August-13	September-13	October-13	July-13	August-13	September-13	October-13	July-13	August-13	September-13	October-13
Temperature	⁰C	31.00	31.50	31.50	29.00	31.00	31.50	31.50	29.00	30.00	30.00	31.00	28.00	30.00	30.00	30.00	28.50
Turbidity	NTU	542	44	42	64	557	96	37	86	798	554	862	378	947	519	640	218
pH	-	7.59	7.48	8.01	7.49	7.87	7.20	7.61	7.38	7.70	7.53	7.63	7.45	7.99	7.50	7.84	7.37
Total Hardness	ppm	140.00	120.00	120.00	104.00	112.00	136.00	124.00	104.00	100.00	112.00	116.00	92.00	104.00	116.00	100.00	92.00
Cl^-	mgL^{-1}	34.00	17.00	14.00	17.00	34.00	17.00	20.00	14.00	14.00	10.00	9.00	14.00	10.00	14.00	10.00	20.00
DO	mgL^{-1}	3.67	1.22	2.04	3.27	3.47	1.84	2.45	3.47	4.69	4.29	4.90	5.51	4.49	3.06	4.49	4.29
BOD	mgL^{-1}	1.24	5.19	2.30	1.73	0.22	5.24	2.73	1.92	0.64	4.98	0.92	1.54	0.84	5.79	0.92	1.97
COD	mgL^{-1}	7.20	7.20	8.60	7.00	8.60	7.80	9.20	7.80	5.60	3.80	10.80	6.80	5.20	4.20	7.40	5.00
Fe	mgL^{-1}	1.13	0.34	0.10	0.21	1.35	0.29	0.13	0.18	1.94	1.45	2.30	0.30	2.60	1.15	1.20	0.70
As	mgL^{-1}	0.001	0.003	0.002	0.002	0.002	0.004	0.003	0.003	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001
Pb	mgL^{-1}	0.014	0.006	0.004	0.005	0.017	0.008	0.005	0.006	0.017	0.018	0.025	0.012	0.012	0.008	0.008	0.004
Cd	mgL^{-1}	0.00094	0.00017	0.00027	0.00017	0.00069	0.00030	0.00015	0.00015	0.00039	0.00017	0.00036	0.00024	0.00043	0.00073	0.00018	0.00019
Cr	mgL^{-1}	0.004	0.003	0.003	0.001	0.005	0.001	0.002	0.002	0.004	0.006	0.006	0.004	0.002	0.001	0.002	0.002

Result of water quality parameter analyses for four selected point of the Vairab River are depicted in Table 5.1. During study period sixteen samples have been collected and analyzed from selected study point. Various Physico-Chemical parameters and fresh water elements of Vairab River water have been studied, compared and discussed as follows.

PHYSICAL PARAMETER

5.1 Local Temperature at Experimental Site and Discussion

Table 5.2 : Temperature of different locations at different months (in degree Celsius)

Sample ID	July-13	August-13	September-13	October-13
V-1	31.00	31.50	31.50	29.00
V-2	31.00	31.50	31.50	29.00
V-3	30.00	30.00	31.00	28.00
V-4	30.00	30.00	30.00	28.50

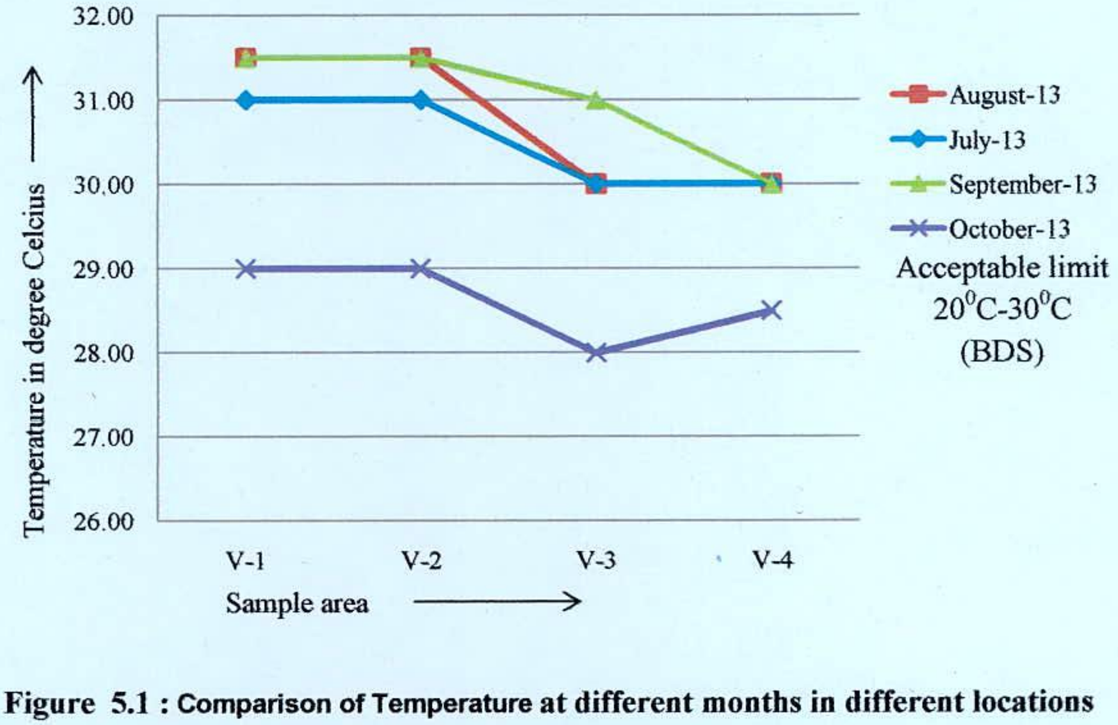


Figure 5.1 : Comparison of Temperature at different months in different locations

The temperature of different location at different months of Vairab River are plotted in figure 5.1. It is observed from the figure 5.1 that in river Vairab the highest temperature (31.5°C) was during August and September at Sankarpasha Ferryghat (V-1) and Akij Leather (V-2) whereas the lowest temperature (28°C) was in October at Kalibari ghat (V-3). High water temperature at Akij Leather (V-2) may be caused by water effluent from industrial activities by Leather factory. Warm water enters the river, raises the temperature of the downstream area. In Sankarpasha Ferryghat, the temperature was high during August and September, because when the temperature was measured the river water was turbid. The sun heated the river water. The turbid water captured more heat from the sun than clear water did. High turbidity levels may increase temperatures [122]. From July to September the average water temperature of Vairab River was above 30°C all of these temperatures were higher than the permissible limit. During these seasons the water of Vairab River was unsafe for drinking purpose, irrigation, recreational activity in respect to temperature.

5.2 Turbidity of Vairab River at Experimental Site during Study Period

Table 5.3 : Turbidity of different locations at different months (Turbidity in NTU)

Sample ID	July-13	August-13	September-13	October-13
V-1	542	44	42	64
V-2	557	96	37	86
V-3	798	554	862	378
V-4	947	519	640	218

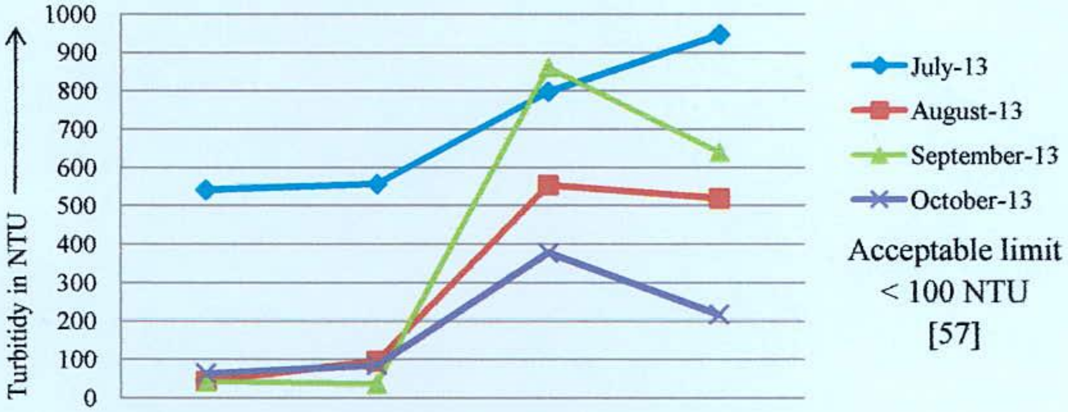


Figure 5.2: Comparison of Turbidity at different months in different locations

The turbidity at different months in different location of Vairab River are plotted in figure 5.2. In this case the highest turbidity (947 NTU) was observed at Labanchara Rupsha ghat (V-4) during July-13 and current turbidity varies with downstream and upstream flows [123].The turbidity of Labanchara Rupsha ghat (V-4) during July-13 was higher due to the downstream river flow and there are some Industries in the bank of the river. Industrial wastewaters may contain a wide variety of turbidity-producing material. In each month the graphical trend of turbidity increases from upstream to downstream. During July-13 turbidity was higher than any other months; this may be due to the fact that at the time of sampling rainfall had been occurred before two days ago. The results of present experiment clearly indicate that the water of Vairab River is almost highly turbid and not suitable for maintaining the normal functioning of aquatic organisms.

CHEMICAL PARAMETER

5.3 pH of Vairab River at Experimental Site during Study Period

Table 5.4 : pH of of different locations at different months

Sample ID	July-13	August-13	September-13	October-13
V-1	7.59	7.48	8.01	7.49
V-2	7.87	7.20	7.61	7.38
V-3	7.70	7.53	7.63	7.45
V-4	7.99	7.50	7.84	7.37

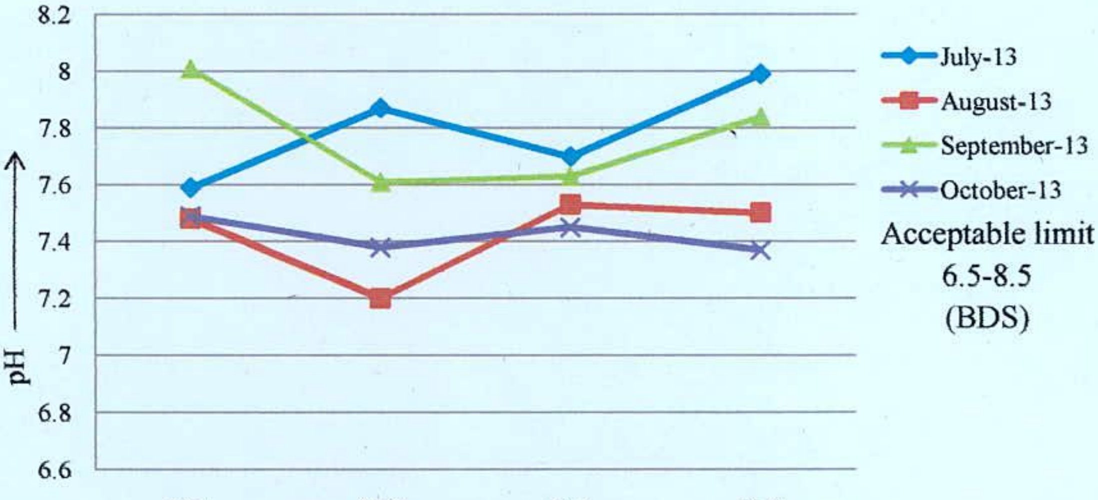


Figure 5.3: Comparision of pH at different months in different locations

The pH of different location at different months of Vairab River are plotted in figure 5.3. It is observed from the figure 5.3 that in river Vairab the maximum pH was 8.01 at Sankarpasha Ferryghat (V-1) in September-13; however, the minimum pH of 7.2 was observed at Akij Leather (V-2) in August. At all the sites pH values were observed within the permissible limit. The relatively high pH (8.01) in September-13 at Sankarpasha Ferryghat may be contributed by the local discharges which contain alkaline effluents from surrounding Bazar and households. High pH of effluents affects physico-chemical properties of water which in turn adversely affects aquatic life, plants and humans. This also changes soil permeability which results in polluting underground resources of water. The results indicate that the water of Vairab River is safe for fish, other aquatic life, irrigation, recreational activity in respect to pH.

5.4 Hardness of Vairab River at Experimental Site during Study Period

The following list is a general guideline for analyzing total hardness in water [124]:

ppm	Classification
0–60	soft
61–120	moderately hard
121–180	hard

Table 5.5 : Total Hardness of different locations at different months (in ppm)

Sample ID	July-13	August-13	September-13	October-13
V-1	140.00	120.00	120.00	104.00
V-2	112.00	136.00	124.00	104.00
V-3	100.00	112.00	116.00	92.00
V-4	104.00	116.00	100.00	92.00

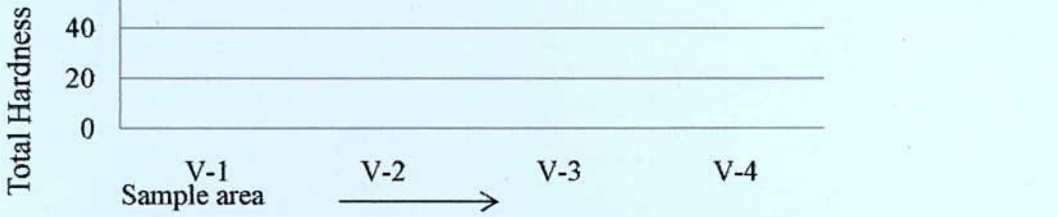


Figure 5.4: Total Hardness at different months in different locations

The hardness of the study area has been plotted in figure 5.4. The maximum hardness of 140 ppm was observed in Sankarpasha Ferryghat (V-1) during July-13 and minimum hardness of 92 ppm was observed in Kalibari ghat (V-3) and Labanchara ghat (V-4) during October-13. From graph it is observed that the hardness is relatively higher at Sankarpasha Ferryghat (V-1).The Himalaya cement factory is situated near the bank of river at Sankarpasha Ferryghat (V-1).The discharge of Himalaya cement factory effluents may contributes to the hardness of the river water. It is important to note that there is no legal limit or standard for hardness in water. This is primarily because the constituents that contribute to hardness are not toxic; that is, they do not cause harmful health effects.

5.6 Chloride of Vairab River at Experimental Site during Study Period

Table 5.7 : Chloride concentration during various months (in ppm)

Sample ID	July-13	August-13	September-13	October-13
V-1	34	17	14	17
V-2	34	17	20	14
V-3	14	10	9	14
V-4	10	14	10	20

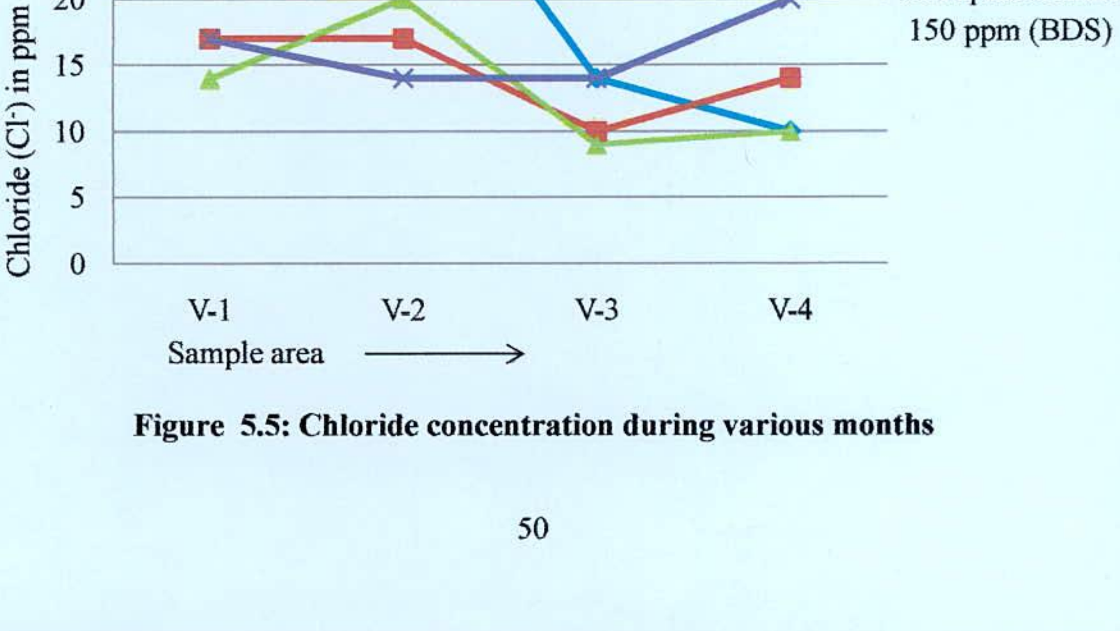


Figure 5.5: Chloride concentration during various months

The Chloride concentration of the study area at different months in different locations has been shown in figure 5.6. The highest value of chloride concentration 34 ppm was observed at Sankarpasha Ferryghat (V-1) and Akij Leather factory (V-2) during July and lowest value of chloride concentration 9 ppm was observed at Kalibari ghat (V-3) during September. The highest value of chloride concentration during July at Sankarpasha Ferryghat (V-1) was due to various kind of mixed potash fertilizer warehouse near Sankarpasha Ferry ghat available. At the time of leather processing, chloride salt is used in Akij Leather factory (V-2), which come in river as industrial effluent. Almost all the values of chloride concentrations during July were higher than any other months during study period. This is due to seasonal variation. The chloride concentrations of the river during study period were in safe limit.

5.7 Dissolve Oxygen (DO) of Vairab River at Experimental Site during Study Period

Table 5.8 : Dissolve Oxygen (DO) of different locations at different months (in mgL^{-1})

Sample ID	July-13	August-13	September-13	October-13
V-1	3.67	1.22	2.04	3.27
V-2	3.47	1.84	2.45	3.47
V-3	4.69	4.29	4.90	5.51
V-4	4.49	3.06	4.49	4.29

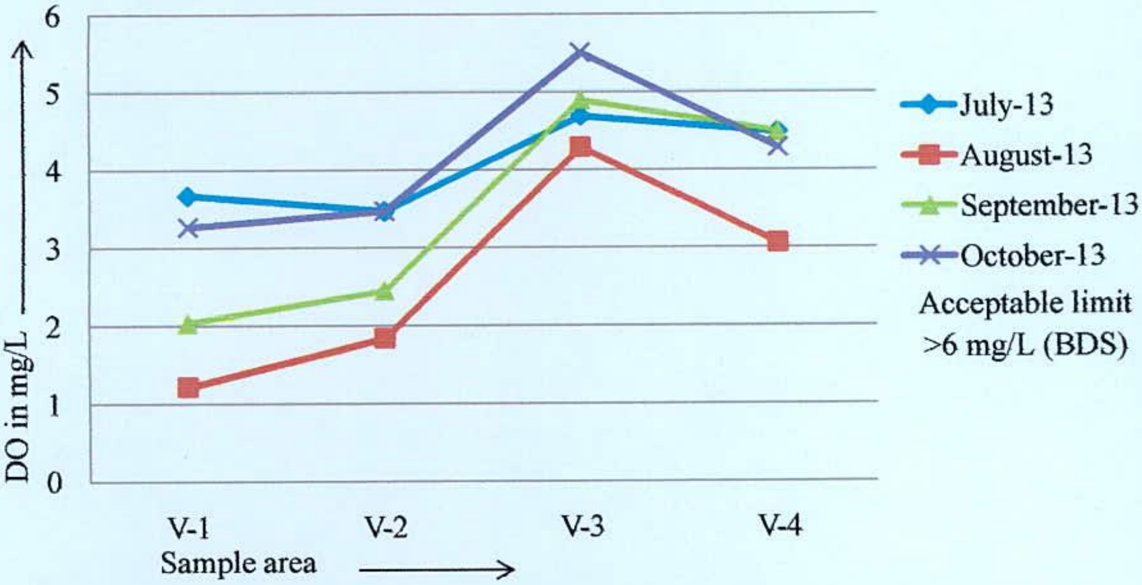


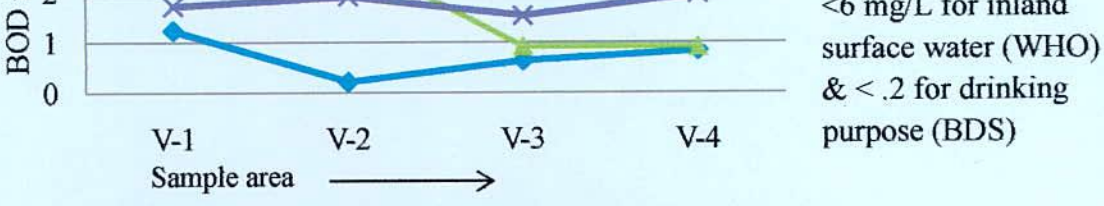
Figure 5.6 : Comparison of Dissolve Oxygen (DO) at different months in different locations

The Dissolved Oxygen of water of the study area at different locations in different months were 1.22 mg/L to 5.51 mg/L which are plotted in figure 5.7. From the observation of the above figure 5.7 it was visualized that the highest DO 5.51 mg/L was observed at Kalibari ghat (V-3) during October and lowest 1.22 mg/L was observed at Sankarpasha Ferry ghat (V-1) during August. All of these DO values of water during study period were not within the permissible limit. These result from excessive algae growth caused by phosphorus. Nitrogen is another nutrient that can contribute to algae growth. As the algae die and decompose, the process consumes dissolved oxygen. Near Sankarpasha Ferry ghat (V-1) industrial and municipal wastes that are discharged to the river through pipeline and runoff sources, such as fertilizers, animal waste, failing septic systems. There are also fertilizer, food, animal and fish feed and various kind of warehouse near Sankarpasha Ferry ghat (V-1) available. So it indicates that during Study period the water of Vairab River was not safe for drinking purpose and irrigation in respect of DO.

5.8 Biological Oxygen Demand (BOD) of Vairab River at Experimental Site during Study Period

Table 5.9 : Biological Oxygen Demand (BOD) of different locations at different months (in mgL^{-1})

Sample ID	July-13	August-13	September-13	October-13
V-1	1.24	5.19	2.3	1.73
V-2	0.22	5.24	2.73	1.92
V-3	0.64	4.98	0.92	1.54
V-4	0.84	5.79	0.92	1.97



Acceptable limit <6 mg/L for inland surface water (WHO) & < .2 for drinking purpose (BDS)

Figure 5.7: Biological Oxygen Demand (BOD) at different months in different locations

The Biological Oxygen Demand (BOD) of water of the study area at different locations in different months were 5.79 mg/L to 0.22 mg/L are plotted in figure 5.8. From the observation of the above figure it was visualized that the highest BOD 5.79 mg/L was at Labanchara Rupsha ghat (V-4) during August and lowest 0.22 mg/L was observed at Akij Leather (V-2) during July. The standard BOD value for inland surface water is 6 mg/L or less and if it is above this value, it can result threat to the aquatic ecosystem. The BOD at Labanchara Rupsha ghat is high due to the disposal of untreated sewage, such as from household latrines on the bank of the river, at the same time this is due to the fact that on the bank of the river near Rupsha ghat, there are many industries of shrimp and prawn fish processing center. From graph it is visualized that the BOD values during August were higher than any other months. Hard rain was taken place before two days ago during sampling which was the cause of high BOD values. From the data and above discussion it is clear that the water of the river during study period were in safe limit for irrigation, domestic use, recreational activities etc. but not good for drinking purpose in respect to BOD.

5.9 Chemical Oxygen Demand (COD) of Vairab River at Experimental Site during Study Period

Table 5.10 : Chemical Oxygen Demand (COD) of different locations at different months (in mgL^{-1})

Sample ID	July-13	August-13	September-13	October-13
V-1	7.20	7.20	8.60	7.00
V-2	8.60	7.80	9.20	7.80
V-3	5.60	3.80	10.80	6.80
V-4	5.20	4.20	7.40	5.00

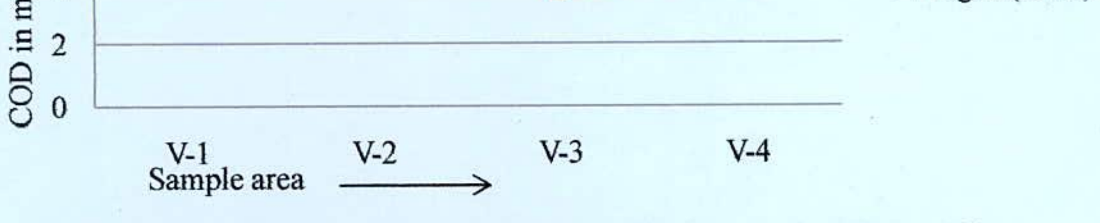


Figure 5.8: Chemical Oxygen Demand (COD) at different months in different locations

The Chemical Oxygen Demand (COD) of water of the study area at different months in different locations of Vairab River were 3.80 mg/L to 10.80 mg/L are plotted in figure 5.9. From the observation of the above figure it was visualized that the highest COD 10.80.mg/L was observed at Kalibari ghat (V-3) during September and lowest COD 3.80 mg/L was observed at Kalibari ghat (V-3) during August. Kalibari ghat (V-3) is a trading station. At the time of sample collection from Kalibari ghat there was raining heavily. There was a runoff from storm water. Contaminated storm water washed off of trading area, called urban runoff was exposed to receiving water body. This may be the cause of high COD values at that point. From the data and above discussion it is clear that the water of the river during study period were not in safe limit in respect to COD.

Fresh Water Elements

5.10 Iron (Fe) of Vairab River at Experimental Site during Study Period

Table 5.11 : Iron of different locations at different months (in ppm)

Sample ID	July-13	August-13	September-13	October-13
V-1	1.13	0.34	0.10	0.21
V-2	1.35	0.29	0.13	0.18
V-3	1.94	1.45	2.30	0.30
V-4	2.60	1.15	1.20	0.70

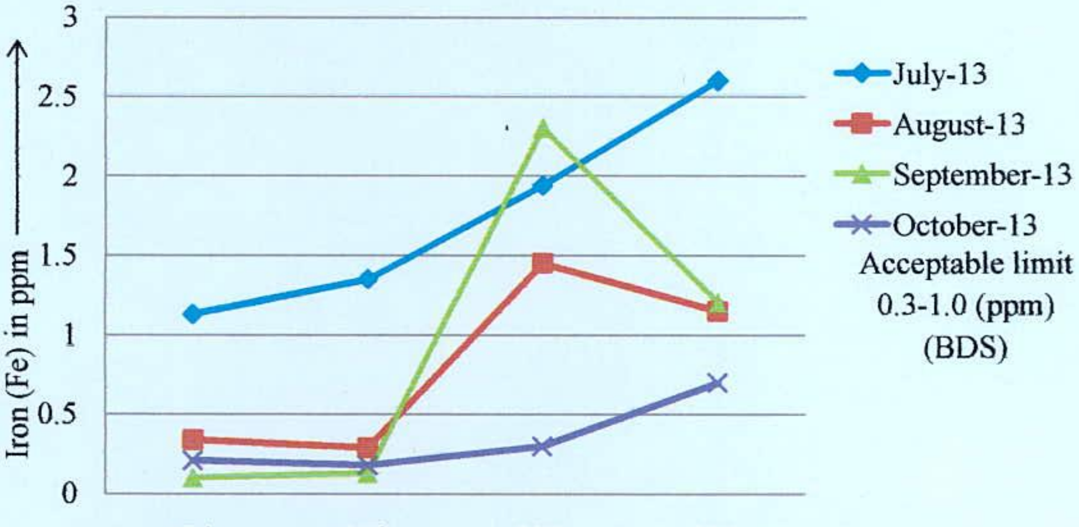


Figure 5.9: Iron at different months in different locations

The concentration of Fe in different locations at different months of Vairab River are plotted in figure 5.10. It is observed from the figure 5.10 that in river Vairab the maximum concentration of Fe was 2.6 ppm during July at Labanchara Rupsha ghat (V-4) whereas the minimum concentration of Fe was 0.10 ppm in September at Sankarpasha Ferryghat (V-1). Iron is the metal that is most abundant on Earth and is therefore very common in soils and water. Labanchara Rupsha ghat (V-4) is a down stream area. So from upper stream, soil particles due to river bank erosion, industrial effluents, municipal sewage etc. introduce into river body. These may be cause of high concentration of Fe in Labanchara Rupsha ghat (V-4).

5.11 Lead (Pb) of Vairab River at Experimental Site during Study Period

Table 5.12 : Lead (Pb) of different locations at different months (in ppm)

Sample ID	July-13	August-13	September-13	October-13
V-1	0.014	0.006	0.004	0.005
V-2	0.017	0.008	0.005	0.006
V-3	0.017	0.018	0.025	0.012
V-4	0.012	0.008	0.008	0.004

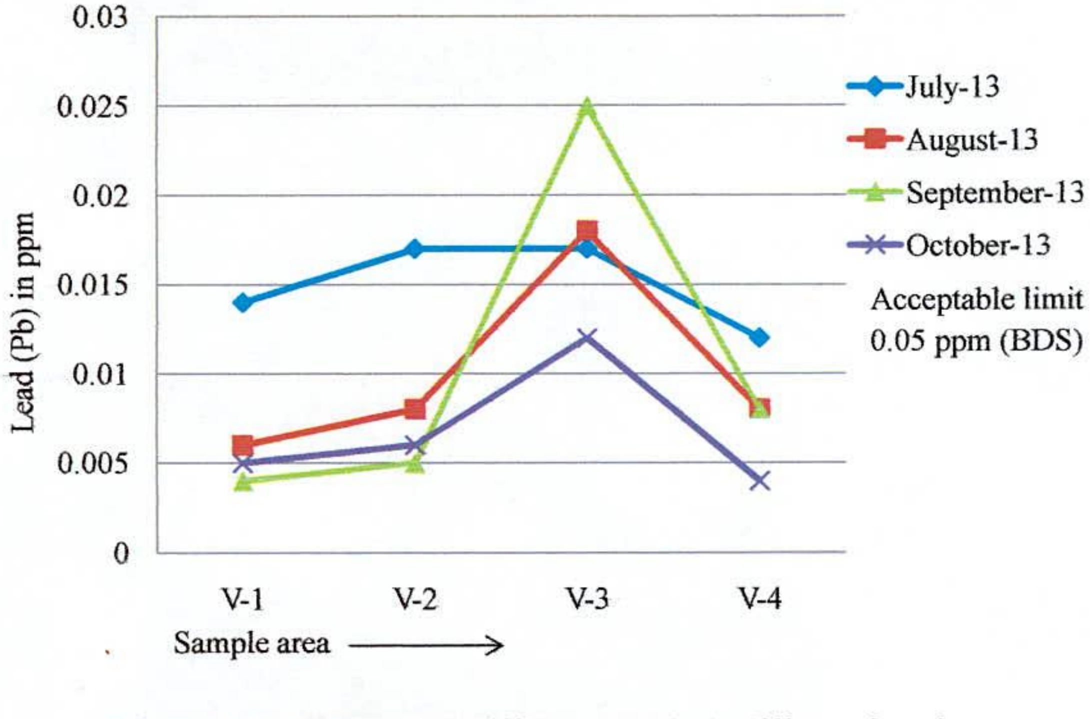


Figure 5.10: Lead (Pb) at different months in different locations

Lead in water of the study area at different locations in different months were 0.025 ppm to 0.004 ppm are plotted in figure 5.11. From the observation of the figure it is visualized that the highest Lead concentration 0.025 ppm was observed at Kalibari ghat (V-3) during September and lowest Lead concentration 0.004 ppm was observed at Sankarpasha Ferry ghat (V-1) during September. The concentration of Lead in the study area did not exceed the permissible limit (0.05 ppm) prescribed by BDS guideline. Comparatively higher value of lead concentration at Kalibari ghat (V-3) is might be due to the addition of civic wastes and industrial effluents from battery manufacturing factory in Shiromony, the industrial area which are also discharging their effluents directly into the river. This is also in agreement with the studies of Javed *et al.*, 1995 [125], Gulfraz *et al.*, 2001 [126] and Naseem *et al.*, 2005 [127].

5.12 Arsenic (As) of Vairab River at Experimental Site during Study Period

Table 5.13 : Arsenic (As) of different locations at different months (in ppm)

Sample ID	Jul-13y	August-13	September-13	October-13
V-1	0.001	0.003	0.002	0.002
V-2	0.002	0.004	0.003	0.003
V-3	0.001	0.002	0.002	0.002
V-4	0.001	0.001	0.001	0.001

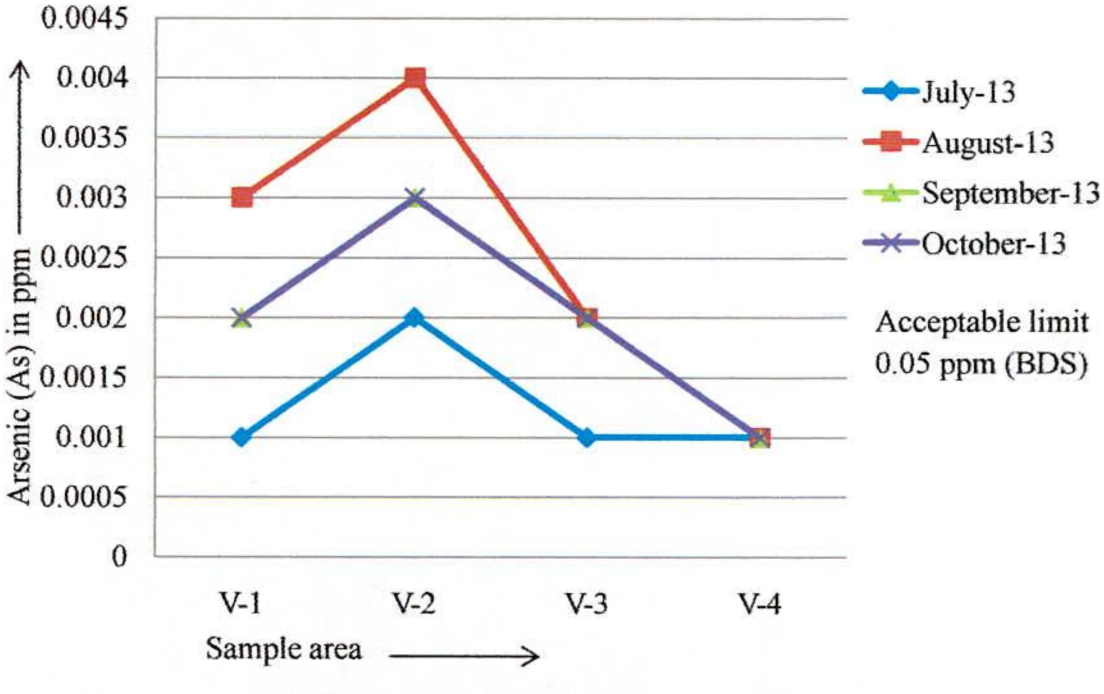


Figure 5.11: Arsenic (As) at different months in different locations

Arsenic in water of the study area at different locations in different months were 0.001 ppm to 0.004 ppm are plotted in figure 5.12. From the observation of the figure it is visualized that the highest Arsenic concentration 0.004 ppm was observed at Akij Leather (V-2) during August and lowest Arsenic concentration 0.001 ppm was observed at Sankarpasha Ferry ghat (V-1) during July. The concentration of Arsenic at different locations in the study area was much below the proposed water quality standards (0.05 ppm).

5.13 Cadmium (Cd) of Vairab River at Experimental Site during Study Period

Table 5.14 : Cadmium (Cd) of different locations at different months (in ppm)

Sample ID	July-13	August-13	September-13	October-13
V-1	0.00094	0.00017	0.00027	0.00017
V-2	0.00069	0.0003	0.00015	0.00015
V-3	0.00039	0.00017	0.00036	0.00024
V-4	0.00043	0.00073	0.00018	0.00019

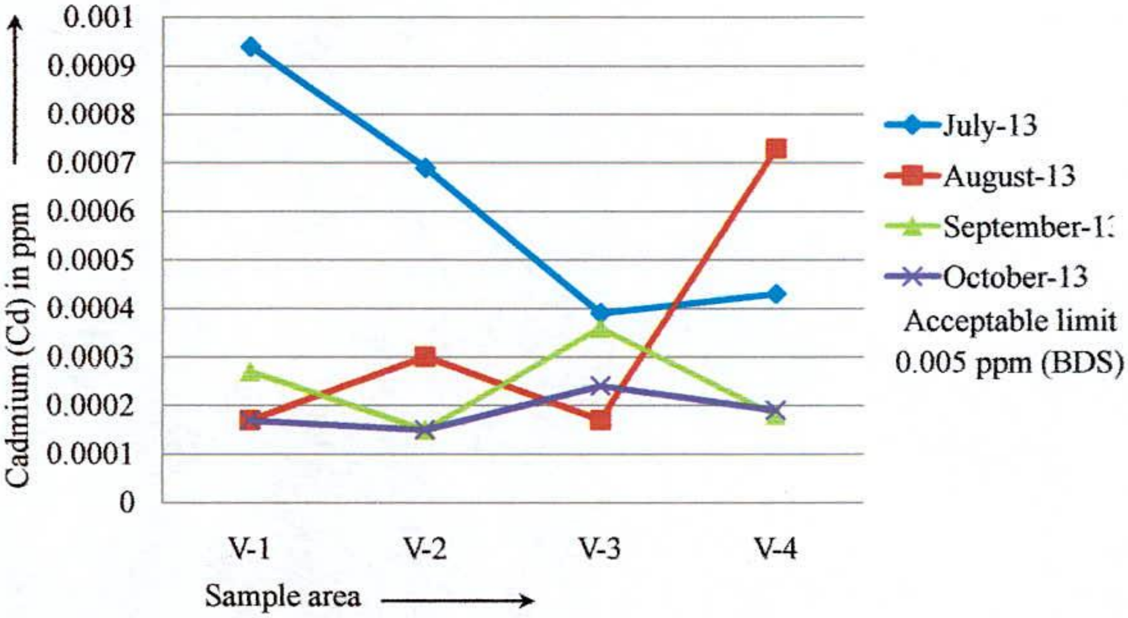


Figure 5.12: Cadmium (Cd) at different months in different locations

Cd concentrations of the study area at different locations in different months are plotted in figure 5.13. At the time of study period the highest value of Cadmium concentration was 0.0094 ppm during July-13 at Sankarpasha Ferry ghat (V-1) and lowest value of Cadmium concentration was 0.00015 ppm during September-13 and October-13 at Akij Leather (V-2). The concentration of Cadmium at different locations in the study area was much below the proposed water quality standards (0.005 ppm). From the data and above discussion it is clear that the water of the river during study period were in safe limit in respect to Cd concentration.

5.14 Chromium (Cr) of Vairab River at Experimental Site during Study Period

Table 5.15 : Chromium (Cr) of different locations at different months (in ppm)

Sample ID	July-13	August-13	September-13	October-13
V-1	0.004	0.003	0.003	0.001
V-2	0.005	0.001	0.002	0.002
V-3	0.004	0.006	0.006	0.004
V-4	0.002	0.001	0.002	0.002

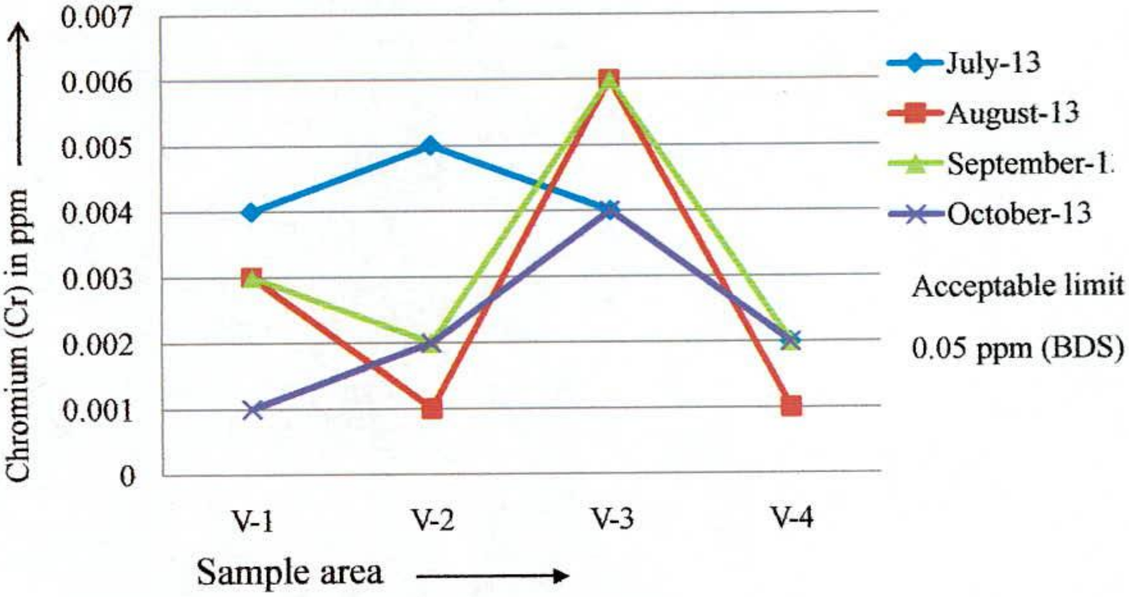


Figure 5.13 : Chromium (Cr) at different months in different locations

In figure 5.14 the Cr concentration of the study area are plotted. At the time of study period the highest value of Chromium concentration was 0.006 ppm during August-13 and September-13 at Kalibari ghat (V-3) and lowest value of Cr concentration was 0.001 ppm during August-13 at Akij Leather (V-2) and Labanchara ghat (V-4), also October-13 at Sankarpasha Ferry ghat (V-1). The concentration of Chromium at different locations in the study area was much below the proposed water quality standards (0.05 ppm). From the data and above discussion it is clear that the water of the river during study period were in safe limit in respect to Cr concentration.

CHAPTER 6

CONCLUSION

CHAPTER 6

Conclusion

The samples of water were collected from different areas of Vairab River from Noapara, Jessore to Labanchara,Khulna, Bangladesh to analyze the physico-chemical parameters and also fresh water elements. The investigation were done during July,2013 to October,2013. The results of the investigation can be summarized as follows:

i. The recorded temperatures was found within 28^0C to 31.5^0C. Maximum temperature was observed 31.5^0C at Sankarpasha Ferryghat, Jessore during August,2013 and minimum temperature 28^0C was observed at Kalibari ghat, Khulna during October,2013. Due to unregulated discharge of wastes into river Vairab, it is unsafe for drinking purpose, irrigation, recreational activities in respect to temperature.

ii. The turbidity was found to be 42 NTU to 947 NTU. During the present study the maximum turbidity was recorded 947 NTU at Labanchara Rupsha ghat, Khulna in July,2013 and minimum turbidity was recorded 42 NTU at Sankarpasha Ferryghat, Jessore in September,2013. Results of present investigation clearly indicate that the water of Vairab River is almost highly turbid and not suitable for maintaining the normal functioning of aquatic organisms.

iii. The value of pH were found 7.2 to 8.01.The minimum pH value was recorded 7.2 at Akij Leather, Jessore during August,2013 and maximum pH value was recorded 8.01 at Sankarpasha Ferryghat, Jessore during September,2013. The water of Vairab River is almost safe for maintaining the daily activities of living organisms in water in respect to pH.

iv. The hardness was observed 92 ppm to 140 ppm. The highest value of hardness was detected 140 ppm at Sankarpasha Ferryghat, Jessore during July,2013 and lowest value 92 ppm was at Kalibari ghat, Khulna and Labanchara ghat, Khulna during October,2013.

v. The chloride concentration was found 9 ppm to 34 ppm. The maximum chloride value 34 ppm was recorded at Sankarpasha Ferryghat, Jessore and Akij Leather factory, Jessore during July,2013. The minimum chloride value 9 ppm was recorded at Kalibari ghat, Khulna during September,2013.

vi. The DO was recorded 1.22 mg/L to 5.51 mg/L. During present study the maximum DO 5.51 mg/L was recorded at Kalibari ghat, Khulna in October,2013 and minimum 1.22 mg/L at Sankarpasha Ferry ghat, Jessore during August,2013. All of the DO values of water during study period were not within the permissible limit. So it indicates that during study period the water of Vairab River is not safe for drinking purpose and irrigation in respect of DO values.

vii. The BOD was recorded 0.22 mg/L to 5.79 mg/L. It was visualized that the highest BOD 5.79 mg/L was at Labanchara Rupsha ghat, Khulna during August,2013 and lowest 0.22 mg/L was at Akij Leather, Jessore during July,2013. Water of the Vairab River during study period were in safe limit for irrigation, domestic use, recreational activities etc. but not good for drinking purpose in respect to BOD.

viii. The COD was found 3.80 mg/L to 10.80 mg/L. The highest COD 10.80 mg/L was observed at Kalibari ghat, Khulna during September,2013 and lowest 3.80 mg/L was at Kalibari ghat during August,2013. From the investigation, it can be recommended that the water of Vairab River is not safe for drinking, irrigation, recreational activities etc. in respect to COD.

ix. The Fe concentrations were recorded 0.10 ppm to 2.60 ppm. Highest Fe concentration 2.60 ppm was at Labanchara Rupsha ghat, Khulna during July, 2013 and lowest 0.0.10 ppm at Sankarpasha Ferry ghat, Jessore during September, 2013. The concentration of Fe in Vairab River was almost high during study period. Though there is no hazardous effect of Fe in respect to health, but it can change the taste, odour and colour of water. Iron deposits on tank, pipelines and restricts the flow of water, reduces water pressure. Some plants with iron staining may experiences a reduction in photosynthesis and vigour.

x. The Pb concentrations were recorded 0.004 ppm to 0.025 ppm. Highest Pb concentration 0.025 ppm was at Kalibari ghat, Khulna during September,2013 and lowest 0.004 ppm at Sankarpasha Ferry ghat, Jessore during September,2013. The Pb concentrations were within standard limit.

xi. The As concentrations were recorded 0.001 ppm to 0.004 ppm. Concentration of As was maximum 0.004 ppm at Akij Leather, Jessore during August, 2013 and minimum 0.001 ppm at Sankarpasha Ferry ghat , Jessore during July, 2013.

xii. The Cd concentrations were recorded 0.00015 ppm to 0.0094 ppm. Maximum Cd concentration 0.0094 ppm was found at Sankarpasha Ferry ghat, Jessore during July, 2013 and minimum 0.00015 ppm at Akij Leather, Jessore during September, 2013 and October, 2013.

xiii. The Cr concentrations were recorded 0.001 ppm to 0.006 ppm. Cr concentration was maximum 0.006 ppm at Kalibari ghat, Khulna during August, 2013, Septembe, 2013 and minimum 0.001 ppm at Akij Leather, Jessore during August, 2013.

Though there are industries, slum-dwellers, bazar, warehouse etc. situated on the bank of river Vairab, the water quality of the river still now hold the permissible limit except temperature, turbidity, DO, BOD (in respect to drinking purpose), COD value and Fe concentration. This is due to the fact that these parameters do not exceed the TMDL values of the river.

The findings of the present study would be helpful as baseline information for developing of monitoring, management and conservation of Vairab river ecosystem in future. However, the investigations covering all the months in a year and more sampling area would be necessary to make concluding remarks on aquatic ecology of the river.

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